THE U.S.-MEXICAN border environment: Progress and Challenges for Sustainability

Edited by
Erik Lee and Paul Ganster

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Series editor, Paul Ganster

Contributors

Anthony J. Brazel	Arizona State University
Christopher Brown	New Mexico State University
José Luis Castro-Ruiz	El Colegio de la Frontera Norte
Javier Chávez	Universidad Autónoma de Ciudad Juárez
Kimberly Collins	California State University San Bernardino
Bobby J. Creel	New Mexico State University
Carlos de la Parra	El Colegio de la Frontera Norte
Salvador Espinosa P.	San Diego State University
Paul Ganster	San Diego State University
Maria Elena Giner	Border Environment Cooperation Commission
María Eugenia González-Ávila	El Colegio de la Frontera Norte
Raúl S. González Ramírez	El Colegio de la Frontera Norte
Alfredo Granados-Olivas	Universidad Autónoma de Ciudad Juárez
Roberto Ham-Chande	El Colegio de la Frontera Norte
John W. Hawley	New Mexico State University
Elaine Hebard	New Mexico-Chihuahua Rural Task Force
Celso Jáquez	New Mexico-Chihuahua Rural Task Force
Francisco Lara-Valencia	Arizona State University
Erik Lee	Arizona State University
Judith Ley García	Universidad Autónoma de Baja California
Erika Mahoney	Arizona State University
Gabriela Muñoz-Meléndez	El Colegio de la Frontera Norte
Lina Ojeda-Revah	El Colegio de la Frontera Norte
Jim Peach	New Mexico State University
O. Alberto Pombo	El Colegio de la Frontera Norte
Ross Pumfrey	Texas Commission on Environmental Quality
Margarito Quintero-Núñez	Universidad Autónoma de Baja California
Rupam Raja	Arizona State University
Juan Manuel Rodríguez Esteves	El Colegio de la Frontera Norte
Erick Sánchez-Flores	Universidad Autónoma de Ciudad Juárez
Allyson Siwik	Gila Conservation Coalition
Sara Sonnenberg	Arizona State University
Al Sweedler	San Diego State University
D. Rick Van Schoik	Arizona State University
Elva Denisse Varela Olivas	Baker & McKenzie LLP
Richard D. Wright	San Diego State University

The Southwest Consortium for Environmental Research and Policy (SCERP) is a consortium of U.S. and Mexican universities dedicated to addressing environmental issues of the U.S.-Mexican border region through applied research, outreach, and regional capacity building.

Arizona State University
El Colegio de la Frontera Norte
Instituto Tecnológico de Ciudad Juárez
Instituto Tecnológico y de Estudios Superiores de Monterrey
New Mexico State University
San Diego State University
Universidad Autónoma de Baja California
Universidad Autónoma de Ciudad Juárez
University of Texas at El Paso
University of Utah

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Paul Ganster

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All times are local.
All monetary figures are US$ unless otherwise specified.

The views of the authors contained herein are not necessarily the views of SCERP, the U.S. Environmental Protection Agency, or the Secretaría de Medio Ambiente y Recursos Naturales. They are presented in the interest of providing a wide range of policy recommendations to prompt discussion and action in the U.S.-Mexican border region.

Contents

Foreword

As past managing director of SCERP and attendee at all 10 Border Institutes, I feel privileged to provide this brief overview on progress made and challenges lingering and emerging for the U.S.-Mexican border environment since 1998.

The vision we articulated for the first Border Institute was straightforward:

> A healthy, sustainable natural environment with an involved binational community, ensuring proper resource management as a basis for a secure and adequate quality of life for all border inhabitants.
>
> A sustainable and responsible border economy that provides all its residents with a satisfactory quality of life through enhanced employment, education, and business opportunities.

Border Institute I participants made 14 recommendations that focused on key areas such as capacity building, financial systems, urban planning, economic development, education, and quality of life. In particular, one recommendation that stands out dealt with the importance of applied environmental research:

> It is imperative that applied environmental research and data analysis be continued and expanded. Research needs to address carrying capacity, alternative low-cost technologies, modeling population to resource demands, and tracking of environmental indicators as warning signals. Moreover, research specifically on institutional and policy issues and environmental behavior has not been well developed for border issues. The vision also includes binational integration of environmental standards, sampling, and analytical methodology.

SCERP's practical, applied approach to border environmental challenges has been key to the progress made in these areas in the years since Border Institute I. A basic component of this approach was engaging key policy networks over the years (through events such as the Border Institute series) to bring applied research to key stakeholders and also to listen closely to these stakeholders' concerns. In particular, analysis of border demographics and population trends garnered the attention of policymakers with a clear and compelling storyline: increasing population in an area of finite resources, particularly water. And as will be apparent in this volume, SCERP researchers continue to make important strides in a majority of these areas.

Both before and after this vision was articulated at Border Institute I, the border region witnessed (some may say endured) some slow but persistent trends as well as some truly transformative events. These include the 1983 La Paz Agreement between the United States and Mexico and the various programs that followed this agreement including the Integrated Border Environmental Plan (IBEP) for the U.S.-Mexico Border Area, Border XXI, and Border 2012. In addition, the border underwent important developments, including demographic momentum with few perturbations in the overall trend; recessions small (2000) and large (2008–2011); enhanced migration enforcement and lack of immigration reform; droughts and floods; new fuels but no new refineries; and the lining of the All-American canal, to name but a few of what can only be characterized as very significant events.

While the United States and Mexico have made great strides in collaborating on difficult issues of binational environmental challenges, what is now clear in retrospect is that the sheer scale and number of challenges facing the border region are truly impressive. These are not small hurdles to overcome and, for the most part, the border environment and therefore the citizens of the border communities suffer more today than in 1998.

Though we may have underestimated the size of the challenges facing the border region, we feel that the Border Institute series has been well worth the effort. The numerous, excellent chapters in this particular volume range from strategic binational issues (security concerns stand out, particularly since 2001) to close analyses of particular subregions of the border region. Together they provide a detailed and very compelling analysis of a broad range of key challenges facing not only the border region but the United States and Mexico more generally for the next two decades.

D. Rick Van Schoik
Director
North American Center for Transborder Studies
Arizona State University
Former SCERP Managing Director

Preface and Acknowledgments

This monograph is the result of Border Institute X, "The U.S.-Mexican Border and a Sustainable Environment in 2030," held in Rio Rico, Arizona, March 8–10, 2010. The tenth Institute continued a tradition of focused discussion on key U.S.-Mexican border environmental issues among a wide variety of border stakeholders, including researchers, public policy analysts, and government officials at various levels.

This type of discussion is more important now than ever before, as the title of this volume suggests. The United States and Mexico have entered a new and highly complex phase of their binational relationship characterized by both progress and challenges. While security remains at the top of the list in terms of binational discussion on public policies, clearly environmental factors are key areas of long-term concern. Water is at the top of a large list of primary concerns and has the potential to actually replace security as the top item on the binational agenda in the coming years.

SCERP and its research network have articulated a deep and sustained interest in a number of important and highly interrelated environmental concerns for many years, and we hope that this monograph continues this tradition of long-term thinking. We have learned a great deal from SCERP researchers over the years, and the work featured in this monograph is no exception. The chapters in this volume, which formed the foundation of the discussions held at Border Institute X, were commissioned with both a long-term vision and an eye on the unique moment in history that we are currently living.

A number of key individuals made Border Institute X successful. The support of our principal partners has been very important; we would particularly like to thank our EPA Program Officer Jerry Kurtzweg of the Office of Air and Radiation for his ongoing support and active participation in SCERP initiatives. In addition we would like to express our gratitude to Bertha Hernández, Devon Howard, and Scott Wagner of the Institute for Regional Studies of the Californias for their extensive efforts in making both Border Institute

X and this monograph possible. We would also like to thank Sara Sonnenberg of the North American Center for Transborder Studies at Arizona State University for her assistance with Border Institute X planning and logistics.

A summary at the end of this volume describes the several excellent presentations given by keynote speakers at various points in the Institute. These include presentations by Sally Spener of the International Boundary and Water Commission; Principal Officer of the U.S. Consulate in Nogales, Sonora, John Dinkelman; Héctor Vanegas of the San Diego Association of Governments (SANDAG); Maria Elena Giner, Managing Director of the Border Environment Cooperation Commission; Carlos de la Parra of El Colegio de la Frontera Norte; and Lisa Almodovar of the USEPA Office of International Affairs.

We thank these and all of the participants in Border Institute X. We believe that through their participation at this and previous institutes, we have added much to the binational discussion through the unique opportunities presented by discussing environmental issues along the U.S.-Mexican border.

Paul Ganster
SCERP Monograph Series Editor

Erik Lee
Associate Director
North American Center for Transborder Studies
Arizona State University

I

U.S.-Mexican Border Population Projections

Roberto Ham-Chande and Raúl S. González Ramírez

Overview

Due to the proximity of Mexico and the United States, close social, economic, and political relationships have always existed. Demographic relationships are particularly important. For example, almost all of the Mexican-origin population that lives outside of Mexico resides in the United States, which is primarily due to significant migration. This demographic dynamic has always been based on economic, political, and regional circumstances that are a part of both countries' history. This demography will also be an essential part of the two countries' shared future. The study and evaluation of this shared demography are necessary for both countries, which have common interests that require binational collaboration.

There are regional considerations within demography; in this regard, the border region is of particular importance. The border region is characterized by daily, frequent, intense, and international interactions. This border reality and the need for planning create the need for projections that allow for the construction of demographic scenarios. Components such as mortality, fertility, and migration all play a role in economic and social variables such as employment, health care, spatial distribution, urbanization, and natural resource and environmental management. These variables and projections should not be understood as the aggregate of parameters between the northern border region of Mexico and the southern border region of the United States, but rather should be considered in terms of the interactions between the two regions.

As is the case with any demographic projection, the point is not to predict the future but rather to construct likely scenarios. These scenarios then allow for the identification of policies and programs to pursue sustainable development. This essay proposes a series of topics and concepts for consideration prior to the implementation of public policies.

Key Elements of Border Demographics

The first step is to define the border region. Due to the urban concentration, social organization, and economy of the border, as a starting point the grouping of the eight principal binational urban systems will be considered as "the border." For this essay, Tijuana-San Diego and Ciudad Juárez-El Paso are examined. The review of these two binational urban systems will serve as a starting point to develop an analysis of the other principal border urban areas in a future project.

The social and economic dynamics of the border are additional key aspects to consider. Significant differences exist between the urban systems on either side of the 3,200-kilometer-long border. These differences include demographic size, the type of economic activities, the geographic medium in which they are settled, and the social and ethnic composition (USMBHA 1994). These differences, in turn, generate differences within the structures and dynamics of their populations. In this essay, a methodology to evaluate each case from a demographic perspective is proposed, developing projections and analyzing the structures of each urban system.

Another key element to consider is the populations that are used to generate the estimates and assumptions. For each case, the projection base will be the cities' 2005 populations and their age and sex structures. The population projections will be made by applying the demographic component method. From a technical perspective, an established model and applications to process these projections will be used. As is the case with all projections, developing a hypothesis regarding the future behavior of the various components will be critical.

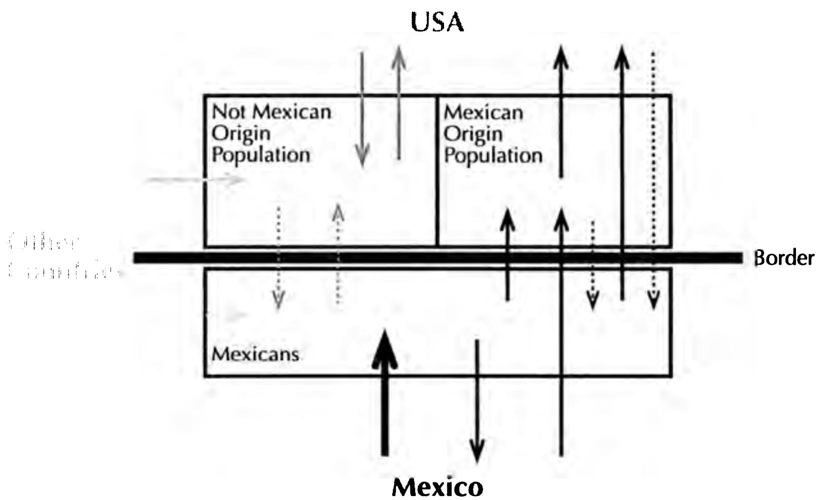
Ethnicity is a fundamental aspect of the social analysis of the U.S. population. From the ethnicity point of view, the border cities of northern Mexico could be considered as simply "Mexican." But in the southwestern United States, ethnic diversity is quite relevant. It is important to clearly distinguish between the Mexican-origin population and the rest of the population, which is mainly Caucasian. The methodological challenge is how to deal with the demographic components of each group, how to consider the interactions *between* groups, and what their cross-border interactions are.

Natural growth is also a key element of population projections. Mortality and fertility are the biological components of demographic dynamics. Here, we seek to understand the levels of each component and what differences exist between northern Mexico and the southwestern United States, throughout the border, and on the U.S. side between the Mexican-origin population and the rest of the population.

One of the main traits of the U.S.-Mexican border is the movement of the population *toward* the region and *within* the region. With respect to migration as a social component of demography, the levels and differentials have very special connotations. We will therefore consider (1) the internal migration within the northern border region of Mexico; (2) migration from the northern border of Mexico toward the southern border region of the United States; and (3) internal migration along the southern border of the United States of both Mexican origin and others (Figure 1).

Additional important aspects to consider are the techniques and the assumptions for estimating future population. The numeric instruments of population projections are automatic for the most part. What really counts is the future hypothesis, both in terms of its feasibility and, above all, its applicability in order to avoid undesirable scenarios and promote better future scenarios. In terms of fertility and mortality rates, the inertia within the phenomena and the sensitivity in terms of change have less significant effects than

Figure 1. Population Movements in the U.S.-Mexican Border Region



Source: Authors.

migration. The relevant discussion, then, centers on the future of migration. Under the current circumstances, the elements that condition migration are employment and family unit.

Finally, once the scenarios have been built and discussed from a demographic and economic point of view, the effects on other variables that have to do with industrial activity, urbanization, energy use, environment, biodiversity, natural resources, water usage, public health, sanitary services, poverty, and climatic change are considered. Then, the concept of "carrying capacity" and what its limits are for physical, social, and economic sustainability are examined. An interdisciplinary research project to be undertaken with a group of researchers from diverse institutions is proposed here.

In summary, the estimates are focused and centered on specific places within the border region. In addition, the population within the southwestern United States has ethnic characteristics that are important and must be considered separately from the Mexican-origin population. And, finally, key demographic components such as mortality and differential birthrate, as well as what is perhaps the most important component—migration—must be taken into account.

Data and Methods

This paper focuses on both the Tijuana-San Diego region at the extreme western end of the border region and the Ciudad Juárez-El Paso region, which is practically in the middle of the border. These two regions include an important part of the border population. San Diego County has the largest ethnic diversity of all border counties. El Paso County has a large percentage of Hispanic residents; according to the U.S. Census, Hispanics make up around 81.8% of the total population of the county,[1] and of this percentage, 84% are of Mexican origin, according to the Texas State Data Center and Office of the State Demographer.[2]

The population projections are based on official data from the second census carried out by the National Institute of Statistics, Geography and Information in 2005 (Instituto Nacional de Estadística, Geografía e Informática–INEGI), the 2000 census in Mexico, and the American Community Survey and estimates done by governmental agencies from the United States that are principally based on information from the U.S. Census Bureau. To carry out the projections, the FIVFIV program from the Office of Population Research at Princeton University was used. This program was originally designed by Frederic C. Shorter, and was later developed by Frederic C. Shorter, Robert Sendek, and Yvette Bayoumy. The program utilizes the demographic components method to perform estimates based on researcher assumptions regarding mortality, fertility, and migration.

The population projections imply making assumptions with regard to the future development of the demographic components. In both Mexico and the United States, mortality has decreased to generally low levels. Both California and Baja California reflect this development, with the main differences being in infant mortality. In 2005, there were 13.38 deaths for each thousand babies born alive in Baja California and 5.30 deaths per thousand babies born alive in California.

With respect to birthrate, the policy on birth control that Mexico has had for almost 40 years has achieved an important reduction in the number of live births within Mexico; the current level is approximately two children per woman. In the case of Baja California and

Chihuahua, it is estimated that, in 2005, women had a global birthrate of 2.18 and 2.34 children per woman, respectively.[3] For the same year in the state of California, there was an equivalent level of 2.19 children per woman (State of California Department of Finance). For Texas, in 2000, the birthrate was 1.92 for white non-Hispanic females and 2.85 for Hispanic females.[4]

Because of the low death and birth rates in Mexico and the United States and the fact that there is no expectation of significant changes within this natural component of demographic growth, for the purposes of our projections we will keep the levels shown throughout the 2005–2030 period constant. The possible bias due to this assumption is relatively low.

The future evolution of migration is a different story. Contrary to the stability of birth and death rates, it is very difficult to predict the behavior of the social component of demographic growth. This is because migration can change from one period to another, since it is more sensitive to policies and actions undertaken by governments on both sides of the border. The approval of a particular migration policy can provoke a substantial increase in the flow of migrants, as occurred with the Immigration Reform and Control Act (IRCA) in 1986. Other examples include Operation Hold the Line and Operation Gatekeeper in the 1990s. These policies—which consisted of the construction of multiple walls along the border in El Paso and San Diego—redirected the flow of migrants toward areas that are more difficult to access and therefore more dangerous. The extreme conditions of the new routes through which undocumented migrants had to pass increased the risk of loss of life.

Two possible scenarios will be constructed in which birth and death rates are constant. In one scenario, it will be shown how population would grow if the migration levels were kept constant and, in the second one, estimates will be made that are based on an increase in migration rates toward the regions of Tijuana and San Diego. Specifically, with regard to El Paso, the Texas State Data Center made estimates taking into consideration five alternative scenarios based on assumptions regarding migration; for this project, only two of them are considered. These include the "0.5 Scenario," which assumes that migration will be 50% of levels during the 1990s (though it is very unlikely that it will return to these levels). The "2000–2007 Scenario" looked at tendencies after the year 2000, particularly those related to migration patterns with regard to age, sex, and ethnicity.

Ciudad Juárez has experienced significant violence in recent years. This has affected migration patterns, and it is assumed that migration to the city has been pushed to other cities in Mexico and the United States. Nevertheless, two possible migration patterns for this city will be considered, assuming that the current levels of violence will not last forever and will even end or significantly diminish at some point. The first assumption is based on migration rates to the city that are close to zero. The second assumption is based on migration recovering slightly.

It should be noted that the estimates made for each year ending in a *5* or a *0* between 2005 (base) and 2030 (end of the projection) are organized by five-year age groups and separately for each sex and each city.

Results

The first estimates for the 2005–2030 period for Tijuana and San Diego were undertaken assuming that the three main demographic phenomena remain constant during the period. Upon the death rate diminishing, as stipulated by the National Population Council (Consejo Nacional de Población–CONAPO), and upon the levels of migration being constant, such as were found in 2005, the population will continue to grow rapidly throughout this entire period, with high growth rates (Table 1). According to these estimates, the population of Tijuana will increase from 1.2 million to almost three million inhabitants, with an annual growth rate above 3% throughout the entire period.

This growth rate is based primarily on migration flows not diminishing, since in the best of scenarios it will remain constant. However, if the Mexican population increases its migration to Tijuana by only an average of 10% for 25 years between 2005 and 2030, this will translate into almost 50,000 more people than the estimate of only constant migration.

In the case of San Diego, population growth is slow rather than explosive. According to Table 2, the population for the county of San Diego in 2005 just surpassed three million; for 2030, it is expected to reach 3.95 million people. The estimates made by the California

Table 1. Tijuana Population Projections: Two Scenarios, 2005–2030

Year	Constant Birthrate Constant Death Rate Constant Migration	Average Annual Growth Rate (%)	Constant Birthrate Constant Death Rate Growing Migration	Average Annual Growth Rate (%)
2005	1,280,692		1,280,692	
2010	1,532,311	3.6	1,545,990	3.8
2015	1,823,308	3.5	1,840,804	3.5
2020	2,155,788	3.4	2,178,236	3.4
2025	2,529,268	3.2	2,562,963	3.3
2030	2,940,547	3.0	2,989,484	3.1

Source: Authors' estimates.

Table 2. Total, Hispanic, and Mexican-Origin Population Projections for San Diego, 2005–2030

Year	San Diego[a]	Average Annual Growth Rate (%)	San Diego Alternative Estimate	Average Annual Growth Rate (%)	San Diego Hispanic Population[a]	Average Annual Growth Rate (%)	San Diego Mexican-origin Population	Average Annual Growth Rate (%)
2005			2,828,014				732,540	
2010	3,199,706		3,059,412	1.6	941,997		803,208	1.8
2015			3,297,590	1.5			877,943	1.8
2020	3,550,714	1.0	3,536,878	1.4	1,125,754	1.8	955,283	1.7
2025			3,772,140	1.3			1,034,004	1.6
2030	3,950,757	1.1	3,995,397	1.2	1,323,945	1.6	1,110,544	1.4

[a] http://www.dof.ca.gov/research/demographic/reports/projections/p3/documents/SAN%20DIEGO.xls

Note: These are only estimates for years ending in zero; consulted on 4 February 2010.

Source: Author's estimates.

Department of Finance, which assume that the demographic components (birthrate, death rate, and migration) will remain constant show that there are currently around 3.2 million inhabitants, of which 942,000 are Hispanic. By 2030, the population will be 3,950,757 people, with 1,323,845 residents being of Hispanic origin.[5] As can be observed, the annual growth rate just exceeds 1%. Demographic change for Hispanics will move a bit faster, with a 1.8% annual increase for 2010–2020 and a 1.6% increase per year for the 2020–2030 period.

The second scenario for San Diego County assumes that migration will remain constant, based on the average level of migrants that San Diego received for three years according to the American Community Survey. The scenario estimates almost four million inhabitants for San Diego County; more than one-fourth would be of Mexican origin. The population growth rate for San Diego County is, by this estimate, only a bit higher than that calculated by the California Department of Finance, assuming that the Mexican-origin population would grow at an even faster rate. This would give the county more than 1.1 million people of Mexican origin. The Mexican-origin population is increasing its size within the overall ethnic composition of San Diego; in 2005, it represented almost 26%, and for 2030 it is expected that this proportion will surpass 27.7%.

In contrast, Table 3 shows that population projections for Ciudad Juárez for the duration of the 2005–2030 period will grow at a slow rate, slightly above 1% per year, and then slowly diminish. In overall terms, there will be an increase of around 500,000 people within 25 years, assuming that total migration is equal to zero. If we assume a slight recovery of total migration, it is expected that the Ciudad Juárez population will increase by approximately 40,000 people in addition to the first estimate.

Table 4 shows the projections for the County of El Paso. At first glance, the total population growth rate in the "0.5 Scenario" follows similar tendencies as those of Ciudad Juárez without migration, even though the population is smaller to begin with. With an absolute increase of a little over 302,000 people, El Paso will surpass one million inhabitants, and for 2030 more that 82% will be of Hispanic origin. In 2005, almost 72% of the population of El Paso was of

Table 3. Ciudad Juárez Population Projections, 2005–2030

Year	Without Migration	Average Annual Growth Rate (%)	With Positive Net Migration	Average Annual Growth Rate (%)
2005	1,225,333		1,225,333	
2010	1,326,714	1.6	1,333,177	1.7
2015	1,426,953	1.5	1,440,919	1.6
2020	1,526,841	1.4	1,549,346	1.5
2025	1,626,078	1.3	1,658,142	1.4
2030	1,720,209	1.1	1,762,711	1.2

Source: Authors' estimates.

Hispanic origin, which means that Hispanic participation within the total population will increase by almost 10% (data not shown), keeping in mind that a significant majority are of Mexican origin.

The "2000–2007 Scenario" shows minor growth rates for El Paso County, including the population of Hispanic origin. The absolute increase will not surpass 200,000; nonetheless, the proportion of Hispanics also shows an increase from 78% to 89% (data not shown). In general, it can be said that one of the "Hispanic" counties of the United States will become even more Hispanic within the next 20 years.

Conclusions

In this essay, population growth tendencies for the municipalities of Tijuana, Baja California, and Ciudad Juárez, Chihuahua, and for the counties of San Diego, California, and El Paso, Texas, have been analyzed. As mentioned earlier, these are not predictions but rather a demographic panorama of what will happen if the population tendencies in the U.S.-Mexican border region continue.

This panorama indicates that the population of Tijuana will continue to grow relatively rapidly, even when taking into account a very low death rate and the birthrate reaching the replacement level. The growth is in great measure due to the migration flows from other states in Mexico. If these migration levels persist for Tijuana,

Table 4. Total and Hispanic Population Projections for El Paso County, Texas, 2005–2030

Year	0.5 Scenario				2000–2007 Scenario			
	Total	Average Annual Growth Rate (%)	Hispanics	Average Annual Growth Rate (%)	Total	Average Annual Growth Rate (%)	Hispanics	Average Annual Growth Rate (%)
2005	740,723		531,654		679,622		531,654	
2010	804,087	1.6	595,485	2.3	725,674	1.3	591,349	2.1
2015	867,475	1.5	662,482	2.1	773,125	1.3	651,192	1.9
2020	928,129	1.4	730,225	1.9	816,573	1.1	705,639	1.6
2025	985,890	1.2	795,318	1.7	850,770	0.8	748,959	1.2
2030	1,043,074	1.1	858,126	1.5	876,437	0.6	782,456	0.9

Source: Table prepared with data estimated by the Population Estimates and Projections Program, Texas State Data Center, Office of the State Demographer, Institute for Demographic and Socioeconomic Research, The University of Texas at San Antonio, February 2009.

by 2040 the city will more than double its current population. This creates an urgent need for more rapid planning in order to satisfy the growth in goods and services necessary to meet the needs of such a dynamic population.

In contrast, the population of San Diego has a relatively low growth rate, mainly because its birthrate is generally below the replacement level. However, the Hispanic population—particularly the Mexican-origin population—continues to increase its relative size due to a higher birthrate and international immigration from Mexico.

A high rate of demographic growth is not foreseen for Ciudad Juárez, which gives planners more time to provide the infrastructure projects that will be needed over the next 20 years. The current violence makes it impossible to foresee a migration panorama other than that of population loss due to security issues.

El Paso County has the least complicated of the scenarios due to its decreasing population growth rate for both Hispanics and non-Hispanics. It does not appear to be affected by the violence within Ciudad Juárez. It is expected that El Paso's demographic phenomenon will continue with the same tendency shown over the last couple of years.

The natural component of demographic growth is controlled by low death rates and by birthrates at the population replacement level. However, the social component of demographic growth, migration, is very sensitive to social and economic events, which determine if its effect diminishes or increases, causing increased pressure and shortages of public services.

Migration control is a task that is somewhat less than impossible. The causes of this demographic phenomenon overwhelm governmental programs, since they respond to the social and economic infrastructure. However, the assumptions used in this project take a more realistic approach than just assuming that migration decreases. Economic and demographic conditions in Mexico do not favor such an assumption. In times of economic crisis, Mexico's population tends to seek employment elsewhere. The North American Free Trade Agreement (NAFTA) has not created the expected number of jobs nor has it diminished the pressure to migrate to the United States. At the same time, the introduction of capital investment into rural areas of Mexico has replaced the traditional forms of production. Communal lands are now sold or rented to large corporations, displacing low-skilled labor and causing increased migration from rural areas to large cities in Mexico and to the United States (Delgado Wise 2006; García Zamora 2002).

All of this leads to the following questions:

1. Are there sufficient land reserves in Tijuana as well as in San Diego to handle such a population increase? In Tijuana, for example, the Valle de Las Palmas region has begun to be developed and is forecasted to contain 250,000 residences for an approximate total of one million people (with four residents on average per household). However, a characteristic of Tijuana is the lack of green areas such as parks and open air spaces. When Valle de Las Palmas is developed with areas for parks and green areas, financial and human resources must be assigned for their maintenance, which is not always done. In the case of San Diego, the San Diego Association of Governments (SANDAG) has studies on topics related to population growth and natural resources, as well as social, economic, and environmental factors, all of which indicate their concern about projected population growth in the region.[6]
2. Do natural resources exist (especially with respect to water) to satisfy growing demand while simultaneously covering current unmet demand? The city of Tijuana currently has a water supply sufficient for the next five years. Ongoing campaigns to save water are focused on water for human usage, which makes up only 10% of total usage, while over 80% of water is destined for agricultural use.
3. Are there plans to address the soil, air, and water contamination that will be generated by the demographic growth of these zones, especially within Tijuana and San Diego?
4. What will happen with other social aspects? For example, do the economic conditions exist to generate the jobs that the new residents of the region will require? Is there sufficient land set aside for educational centers at all levels? There is currently a branch of the Autonomous University of Baja California in Valle de Las Palmas, but school-age children make up the largest proportion of potential students for the substantial population expected for the area. The same questions regarding health and other services should also be asked.

These are some of the questions that arise with respect to projected demographic growth within the region. They should be analyzed in a binational and multidisciplinary manner with the purpose of designing policies that address these problems.

Endnotes

[1] http://factfinder.census.gov/servlet/QTTable?-ds_name=PEP_2008_EST&-qr_name=PEP_2008_EST_DP1&-geo_id=05000US48141 (consulted 30 March 2010).
[2] http://txsdc.utsa.edu/txdata/sf1/cnty_prof.php. El Paso (consulted 30 March 2010).
[3] http://www.conapo.gob.mx/index.php?option=com_content&view=article&id=125&Itemid=193 (consulted 15 March 2010).
[4] http://txsdc.utsa.edu/tpepp/2008projections/2008_txpopprj_txtotnum.php (consulted 30 March 2010).
[5] According to information from the 2000 Census for San Diego, it is estimated that a little more than 80% of the Hispanic population is of Mexican origin.
[6] See www.sandag.org for an explanation of each one of the programs to which effort and dedication has been applied.

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II

The Aging of the Border Population

Jim Peach

INTRODUCTION

Environmental issues of the U.S.-Mexico borderlands would attract (and deserve) little attention in the absence of the region's rapid population growth in the last half century. A relatively young population has been a key factor in border region growth (Peach and Williams 2001; Anderson and Gerber 2008). In-migration and natural increase fueled the border population boom. Migration and natural increase are age-related demographic processes. Migrants to the border are more likely to be young than old. Common summary measures of fertility such as the crude birth rate (CBR) or the total fertility rate (TFR) disguise the fact that fertility is an age-related phenomenon. Demographic momentum is the name given to the tendency of a disproportionately young population to grow even in the face of low or declining fertility rates.

The border population is aging, a reflection of national trends in both the U.S. and Mexico. Few, if any, significant social, demographic, or economic variables will be left untouched by the aging of the border population. The aging process will force us to reexamine most of what we think we might know about border region development, transborder interaction, and regional environmental issues. Old assumptions and previously reliable trends in the region will, sooner rather than later, appear unwarranted.

Border population aging will, of course, affect future population growth through diminished in-migration and reduced natural increase. But those changes are only the beginning. The age distribution of a population is a major determinant of the size and growth of the labor force (Bradshaw and Frisbee 1983). Aging is also an important factor in determining the distribution of income and wealth. Young people simply do not enter the labor force at the high end of the income distribution—nor, for the most part, do young people have substantial savings. The consumption of both durable and non-durable goods is age dependent. The demand for housing is particularly sensitive to age-related events such as marriage, divorce, children leaving home, or the death of a spouse. The volume and composition of imports and exports is at least partly age related.

Age is also an important determinant of the demand for public services, particularly education and health care. The so-called social security problem is an aging phenomenon. The capacity of governments at all levels to raise revenue to provide needed public services is also partly a function of the age distribution of the population. In response to changes in the demand for public and private goods and services, changes in the composition of industry are also likely to occur. The environmental consequences of these dramatic changes are not difficult to imagine. The border region will be a very different place and will present even more complex environmental issues in two or three decades.

No one should assume, however, that population aging is the only game in town. Aging is a demographic process that occurs in a broader context. Economic conditions in Mexico and the U.S. will remain important parts of the border equation. Will the U.S. economy experience a long period of slow (Japanese style) growth? Will Mexico's economy experience a prolonged period of growth and stability? Will there be yet another global financial crisis? The various plausible macroeconomic scenarios in the two nations will also profoundly change the nature of the border region. National policy responses to key issues such as trade, energy, immigration, health care, and education will also play an important role in shaping the future of the border region.

The main purpose of this paper is to examine recent trends of a once youthful, but now aging border population. The section that follows provides a justification for assertions in the introduction concerning the importance of age in migration, fertility, and labor supply. The "Aging in the U.S. and Mexico" section establishes the national context in which border region aging takes place. "Aging in the Border States" examines aging in the 10 border states (California, Arizona, New Mexico, Texas, Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas). The section on "Aging in Border Counties and *Municipios*" examines aging in the 10 largest county and *municipio* urban agglomerations along the border. The final section contains concluding remarks.

A Digression on Age-related Phenomena

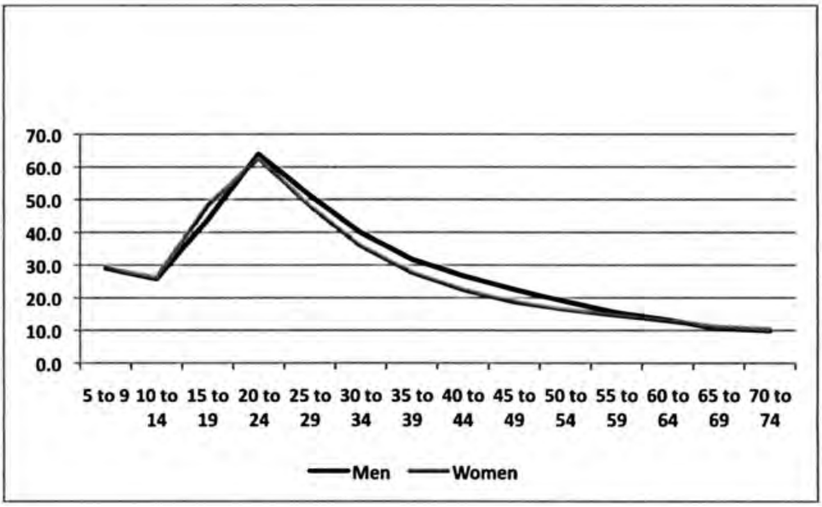
Claims were made in the introduction that migration, fertility, and labor force participation are age dependent. An explanation of these assertions follows.

Migration to the borderlands, like most migration flows throughout the world, is mainly a migration of young people. Figure 1 displays migration rates to Mexico's six border states from other states in Mexico in 2005. The migration rates were calculated from the micro data samples of Mexico's 2005 *Conteo* (Count) (INEGI 2010). The micro data files allow computation of tables not generally published. Mexican migration rates shown are five-year migration rates. That is, the question asked in the *Conteo* was where the individual was five years earlier.

For both men and women, migration rates to the border states increase sharply beginning at very young ages. The peak migration rate is in the 20- to 24-year-old age group for both men and women. After age 25, migration rates decline sharply and nearly disappear after age 75. Two-thirds (66.1%) of the migrants to the border states were under the age of 30.

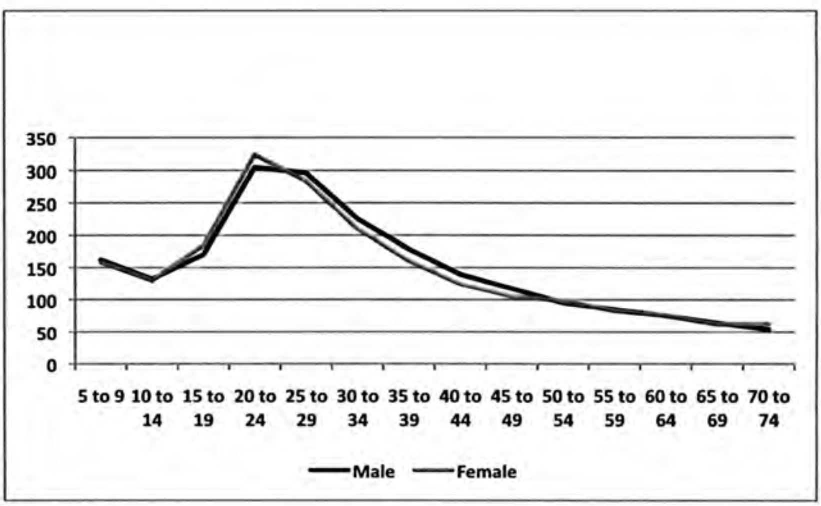
Migration rates to the U.S. side of the border appear in Figure 2. These rates were compiled from the Public Use Micro Sample data files of the 2008 American Community Survey (ACS) (U.S. Bureau of the Census 2010). The migration question in the ACS refers to residence one-year earlier—in contrast to the five-year period in

Figure 1. Migration Rates by Age:
Mexican Border States, 2005



Source: Author.

Figure 2. Migration Rates by Age:
U.S. Border States, 2008



Source: Author.

Mexico's 2005 *Conteo*. The migration rates refer to migrants from other states to the four U.S. border states (California, Arizona, New Mexico, and Texas).

While U.S. migration rates to the border states are higher than in Mexico, the pattern with respect to age is remarkably similar. As in Mexico, migrants to the U.S. border states are predominantly young. Also similar to the pattern in Mexico, migration rates rise sharply and reach a peak in the 20- to 24-year-old age group for both men and women. After age 25, migration rates fall sharply and, as in Mexico, virtually disappear after age 75. Although not shown here, migration rates to the border counties and *municipios* have substantially the same pattern with respect to age.

An aging population in migrant sending areas (the non-border states of Mexico and the U.S.) will affect migration flows to the border region and, hence, future border region population growth rates.

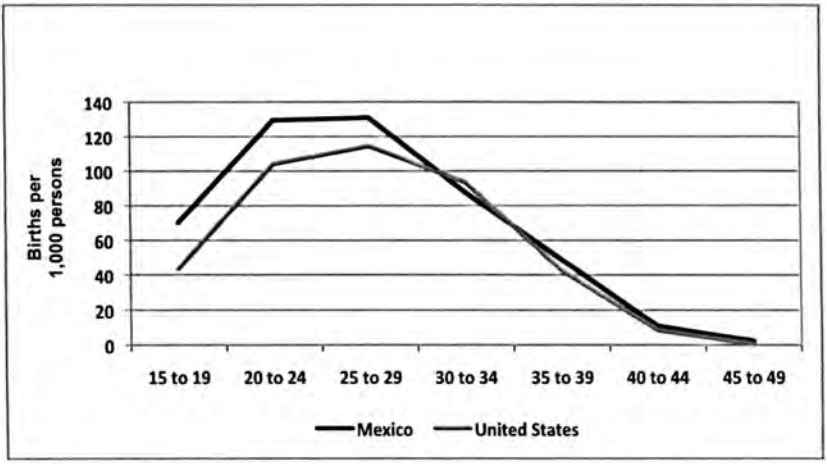
Border region population growth has also been fueled by natural increase (the excess of births over deaths). A young population contributes to natural increase even in the face of stable or declining total fertility rates—a phenomenon known as demographic momentum.

Women are more likely to give birth at some ages than at others. Figure 3 displays births per 1,000 women by age in Mexico and the U.S. during the 2000 to 2005 period. In the U.S. and Mexico, birthrates rise quickly from the teen years to the twenties and then begin falling rapidly. Births among women beyond age 45 do occur but are numerically insignificant.

Birthrates in the border states and sub-state areas differ somewhat from the national averages shown in Figure 3, but the general pattern with respect to age is strikingly similar. The key point is that, as the population ages, a smaller proportion of border region women will be in the high fertility age groups. As with migration, aging of the border population implies slower future population growth rates.

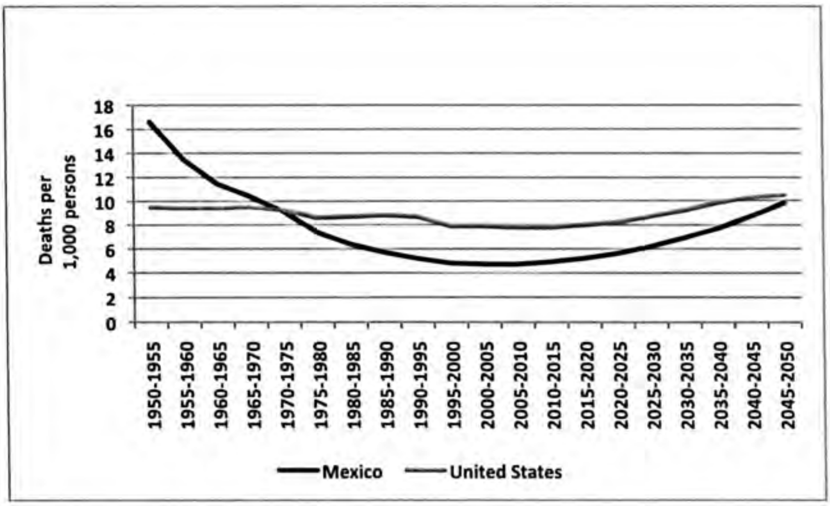
The other part of natural increase is the death rate. Death rates are also age specific. Figure 4 shows crude death rates (CDRs) in the United States and Mexico from 1950 to 2050. CDRs declined in Mexico (substantially) and in the U.S. (slightly) between 1950 and 2000. CDRs in both the U.S. and Mexico are projected to increase between the early 2000s and 2050. This increase in CDRs is an age-related phenomenon.

Figure 3. Crude Birthrates in the United States and Mexico



Source: United Nations, Population Division, 2008.

Figure 4. Crude Death Rates in the United States and Mexico, 1950–2050

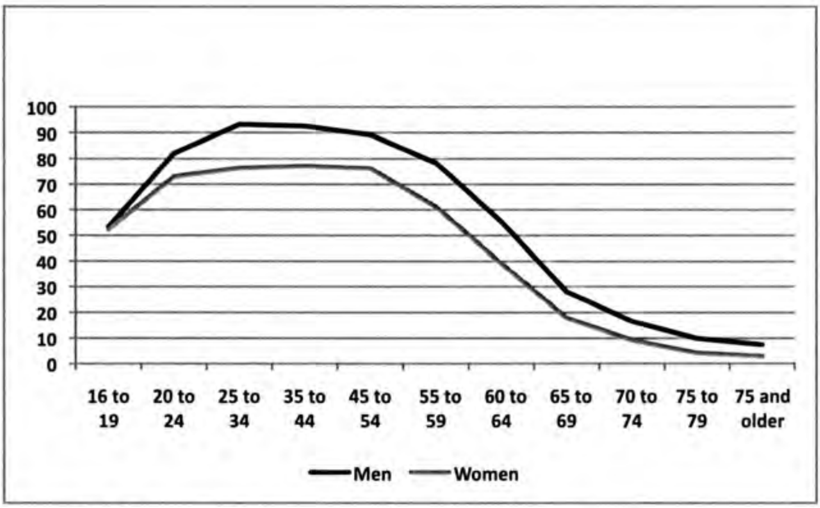


Source: United Nations, Population Division, 2008.

Major consequences of border population aging will occur in labor markets (Matheny 2009). Labor force participation rates (LFPRs) exhibit similar patterns with respect to age nearly everywhere. LFPRs for both men and women begin to rise in the teen years, reach a peak in the early twenties, remain at high levels until the fifties, and drop dramatically after about age 55.

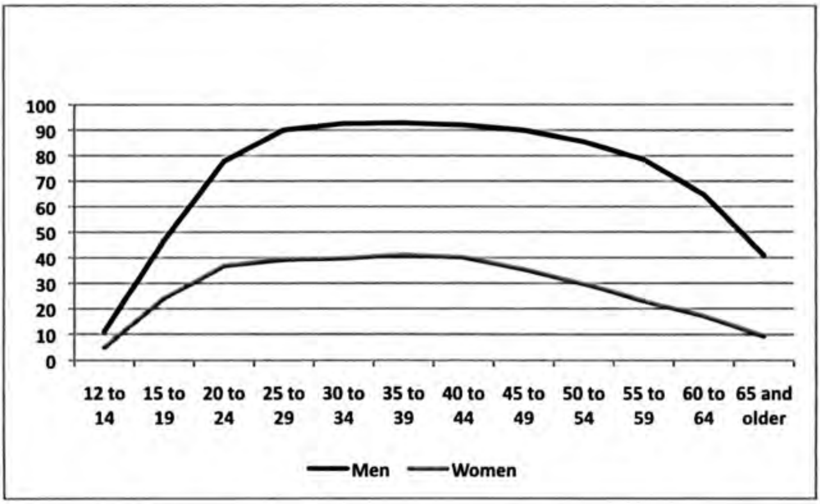
The pattern described previously is shown in Figure 5 for the U.S. in 2008. Strictly comparable data for Mexico are not available, but Figure 6 shows the proportion of the population 12 years old and older that was economically active in 2000.

Figure 5. Labor Force Participation Rates of Men and Women in the U.S., 2008



Source: U.S. Bureau of Labor Statistics, http://www.bls.gov.

Figure 6. Economically Active Population in Mexico as Percentage of Age Group, 2000 Census

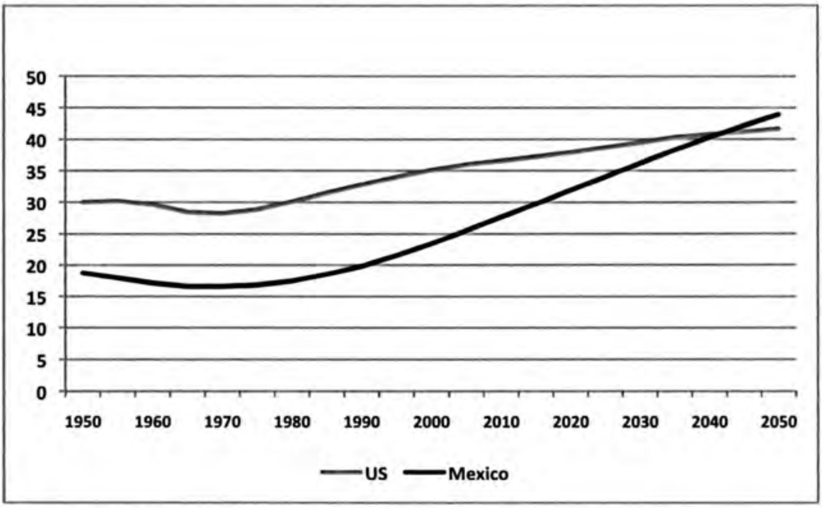


Source: INEGI 2000.

Aging in the United States and Mexico

Aging is an important feature of the populations of Mexico and the United States. In the border region, aging reflects these national trends. The median age in both nations has been increasing since the 1970s (Figure 7).[1] In 1970, the median age in the U.S. was 28.2 years while in Mexico the comparable figure was 16.6 years—somewhat more than half the U.S. figure. According to the United Nations (2008) "medium variant" projections, median ages in Mexico and the U.S. will continue to increase through 2050—the last year of the projections. As shown in Figure 7, median ages in the U.S. and Mexico are converging rapidly. By 2040, the median ages are approximately equal (U.S. = 40.8 years and Mexico = 40.3 years). By 2050, Mexico's projected median age (43.9) is higher than the projected U.S. median age (41.7).

Figure 7. Median Ages in the U.S. and Mexico, 1950–2050

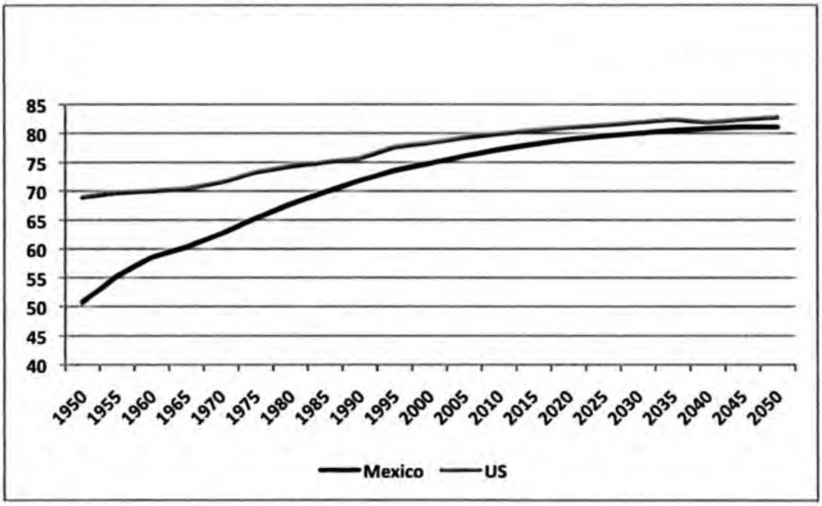


Source: United Nations, Population Division, 2008.

Increases in life expectancy at birth (Figure 8) and generally decreasing total fertility rates (Figure 9) contribute substantially to the increasing median ages in the two nations. The increase in life expectancy in Mexico has been particularly dramatic. Mexico's 1950 life expectancy of 50.7 years increased to 76.1 years by 2000. U.S. life expectancy increased from 68.9 years to 78.3 years from 1950 to 2000. Most of the gains in life expectancy in the two nations have probably already occurred. The UN projections indicate only modest increases in life expectancy (Figure 9) through 2050 with life expectancy in both nations in the low eighties.

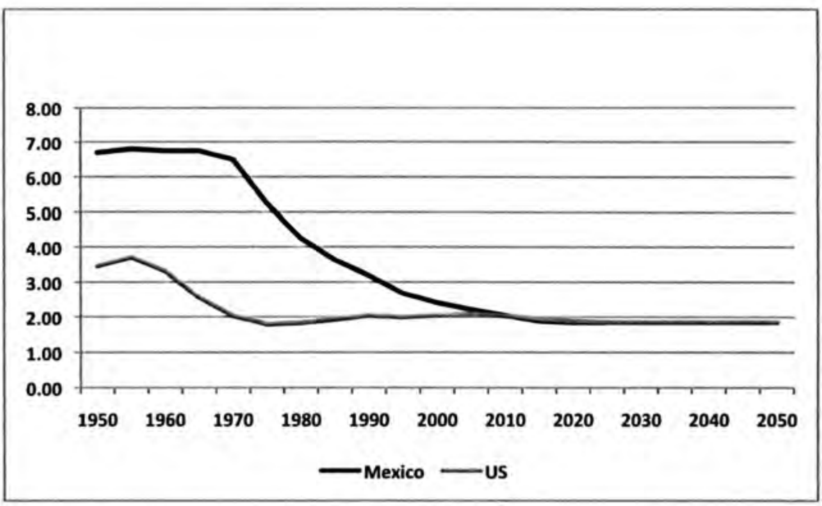
A substantial downward trend in fertility in Mexico has been apparent since the mid-1970s. A little history is important to understand this phenomenon. In the 1930s, Mexico deliberately pursued a pro-natalist, high population growth strategy. The logic behind this strategy was two-fold. First, Mexican policymakers thought that a highly populated Mexico (particularly its northern border states) would be less attractive to annexation by the U.S. Second, it was assumed that Mexican economic growth had been inhibited by a small labor force and small domestic market. The policy worked. From the 1930s to the early 1970s Mexico's fertility and population

Figure 8. Life Expectancy at Birth: Mexico and the United States, 1950–2050



Source: United Nations, Population Division, 2008.

Figure 9. Total Fertility Rates in the U.S. and Mexico, 1950–2050



Source: United Nations, Population Division, 2008.

growth rates were high. In 1973, Mexico adopted a series of policy measures designed to reduce population growth. The new policies also worked. Mexico's total fertility rate began to drop noticeably by the mid-1970s.

In the U.S., the baby-boom generation (born 1946–1964) changed the age distribution dramatically beginning in the late 1940s. The U.S. baby-boom generation continues to affect the age distribution. A baby-boom echo was clearly observable in the 1990s. Over the next decade, the millions of the first born baby boomers will retire and create unprecedented changes in public and private retirement systems.

Figures 10 through 19 are population pyramids for Mexico and the United States beginning in 1950 and continuing through 2050 at 25-year intervals. The changes in the age structure of the two populations previously described are not difficult to discern in the pyramids. In 1950 (Figure 10), Mexico's age distribution exhibited the classic pyramid shape that these figures are named after. In 1950, 52.7% of Mexico's population was under 20 years old. In contrast, 34.1 percent of the U.S. population was less than 20 years old in 1950, despite the start of the baby boom (Figure 11).

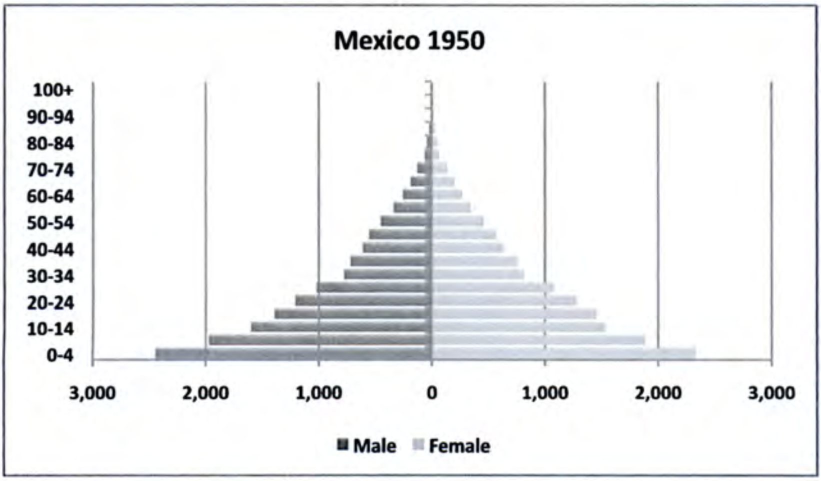
In 1975 (Figure 12), Mexico's age distribution was still the classic pyramid shape and 47.6% of the population was still under the age of 20. In the U.S. in 1975 (Figure 13), the end of the baby boom is apparent and only 23.3% of the population was under the age of 20.

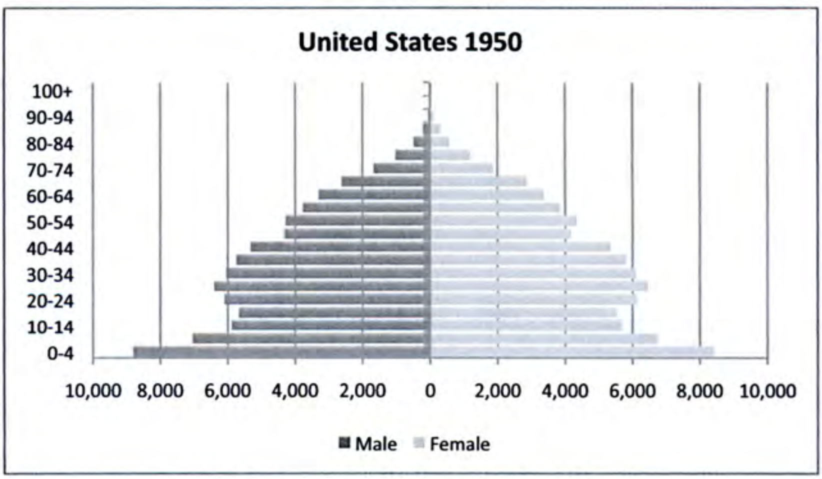
By 2000, the aging of both populations is obvious. Mexico's 2000 pyramid (Figure14) is beginning to lose its classic pyramid shape. Figure 15 shows the baby-boom echo and the aging of the population in the U.S. in 2000.

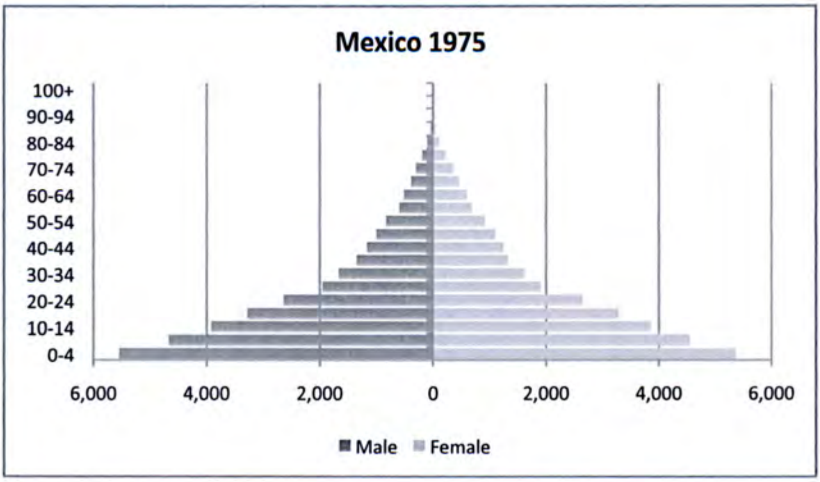
By 2025, the aging of both populations is a dominant feature. In Mexico (Figure 16), the classic pyramid shape of the age distribution is nearly gone and only 28.7% of the population is below age 20. In the U.S. (Figure 17), large numbers of baby boomers are now above age 65.

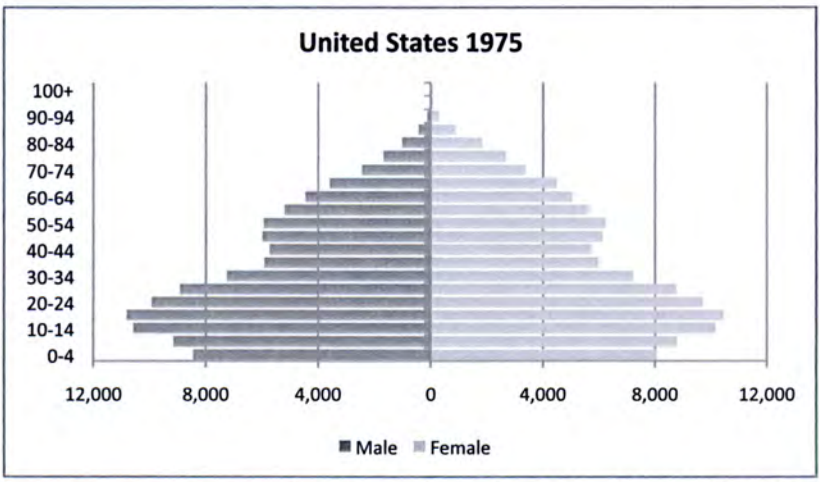
By 2050, more than one-fourth of the populations of both nations (28.2% in Mexico and 27.4% in the U.S.) are 60 years old or older (Figures 18 and 19). Even a glance at the pyramids over time reveals dramatic changes in the two age distributions.

Figures 10–13. Age Distribution of the Populations of Mexico and the U.S., 1950–1975



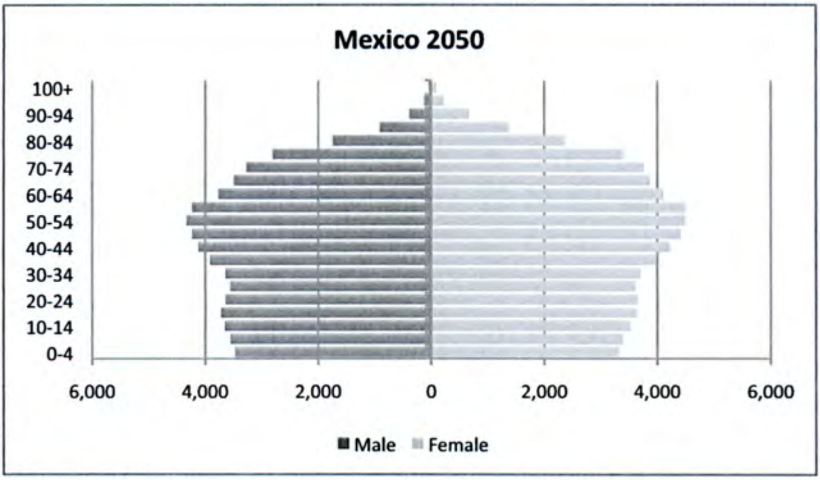


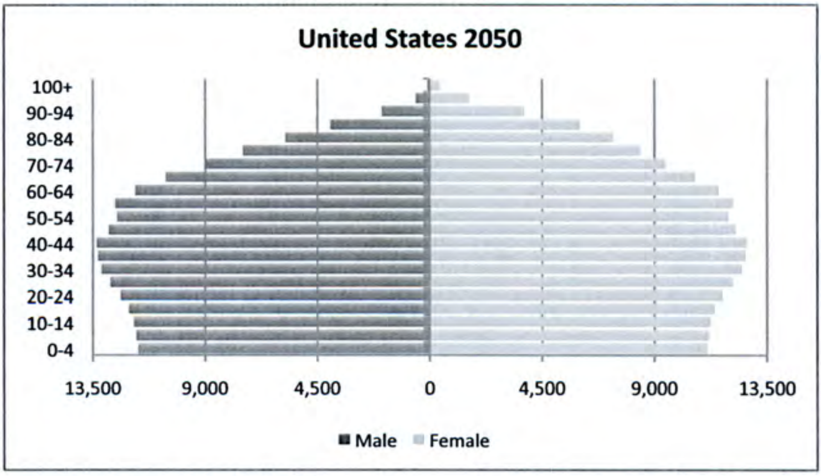




Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2008 Revision*, http://esa.un.org/unpp. January 13, 2010. Figures constructed by the author. The data are from the UN "medium variant" projections.

Figures 18–19. Age Distribution Projections for the Populations of Mexico and the U.S., 2050





Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2008 Revision*, http://esa.un.org/unpp. January 13, 2010. Figures constructed by the author. The data are from the UN "medium variant" projections.

Aging in the Border States

Historically, the U.S. border states (Table 1) have had a younger population than the nation as a whole. In 1950, three of four border states had a median age less than the national average and by 1960 all four border states had median ages less than the national average. Consistent with national trends, border state median ages began to rise in the 1970s. Figure 20 illustrates the importance of the national trend for the four border states. While median ages differ in the border states, the trend in each state is remarkably consistent with the national trend. By 2000, all four border states had median ages in the low thirties although none exceeded the national average. Census Bureau projections suggest that median age in Arizona and New Mexico will exceed the national median by 2020 and this could occur when the 2010 Census is completed.

Figures 21 through 28 are population pyramids for the combined U.S. border states. Pyramids are shown at 10-year intervals from 1960 to 2030.[2] The figures illustrate graphically the aging of the border state populations. Also illustrated is the fact that demographic events last a long time. For example, the baby boom is obvious in the 1960 pyramids. Further, the baby boom and its echo are clearly visible in the 1990 pyramid. In fact, the aging of the baby-boom generation can be seen in the border state pyramids through 2030.

Median ages for Mexico's six border states are displayed in Table 2. In 1960, five of Mexico's six border states had a median age higher than the national average and, by 1980, none of Mexico's border states had a lower median age than did Mexico as a whole. The differences between the border states and the nation are, however, small. Median ages in the six Mexican border states have averaged about one year above the national figure (Table 2). Mexico's border states, like the U.S. border states, are aging rapidly. By 2000, Mexico's border states had a median age of 24.1 years—nearly seven years higher than in 1960. By 2020, all of Mexico's border states are projected by the National Population Council (Consejo Nacional de Población–CONAPO) to have a median age above 30 and the median age for the border states will reach 35.0 years by 2030—a figure more than double the border states median age in 1980 (17.4), but less than the projected national median of 36.2 years.

Table 1. Median Ages in the Border States

State	1960	1970	1980	1990	2000	2010	2020	2030
California	29.1	28.1	29.9	31.5	33.3	34.9	35.7	37.4
Arizona	25.7	26.3	29.2	32.2	34.2	36.4	38.2	39.3
New Mexico	22.9	23.9	27.4	31.3	34.6	38.3	41.2	44.8
Texas	27.0	26.4	28.0	30.8	32.3	33.4	34.3	34.6
Border States	28.5	27.3	30.2	31.3	33.1	34.6	35.6	36.3
United States	29.5	28.1	30.0	32.9	35.3	36.6	37.9	39.5

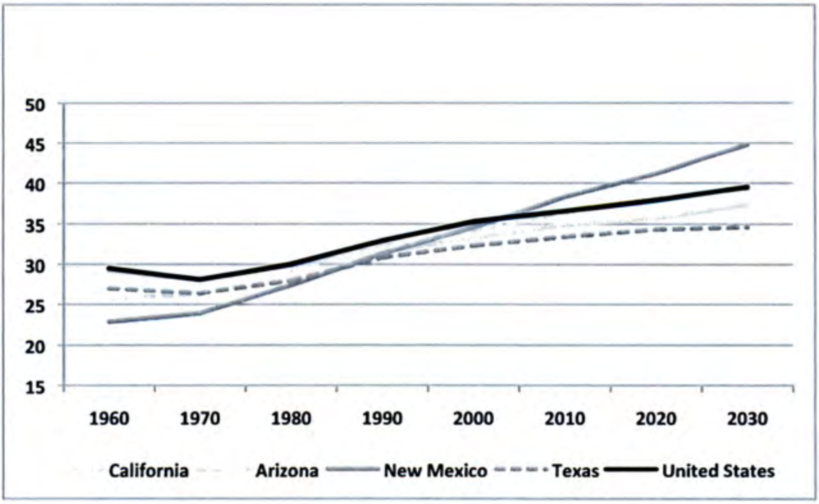
Sources: 1950 to 2000: U.S. Bureau of the Census, Census of Population and Housing (1950, 1960, 1970, 1980, 1990, and 2000), state volumes, http://www.census.gov/prod/www/abs/decennial/index.htm.
2010 to 2030, U.S. Bureau of the Census, State Population Projections, Issued 2005, http://www.census.gov/www/projections/statepyramid.html.

Table 2. Median Ages in Mexico's Border States: 1960–2030

State	1960	1970	1980	1990	2000	2010	2020	2030
Baja California	17	16.4	18.8	21.2	23.5	27.2	30.2	33.3
Sonora	17.5	16.8	18.4	20.9	23.9	27.4	31.6	35.8
Chihuahua	17.7	16.6	18.3	20.9	23.6	27.3	31.5	35.8
Coahuila	17.9	16.9	18.0	20.5	23.7	26.9	30.9	35.0
Nuevo León	19.4	17.5	18.5	21.5	24.9	28.3	32.1	35.6
Tamaulipas	18.2	17.1	18.5	21.2	24.2	27.7	31.8	35.8
Border States	18.1	16.9	18.4	21.1	24.1	27.6	31.3	35.0
Mexico	17.1	16.6	17.4	19.8	23.4	27.6	31.9	36.2

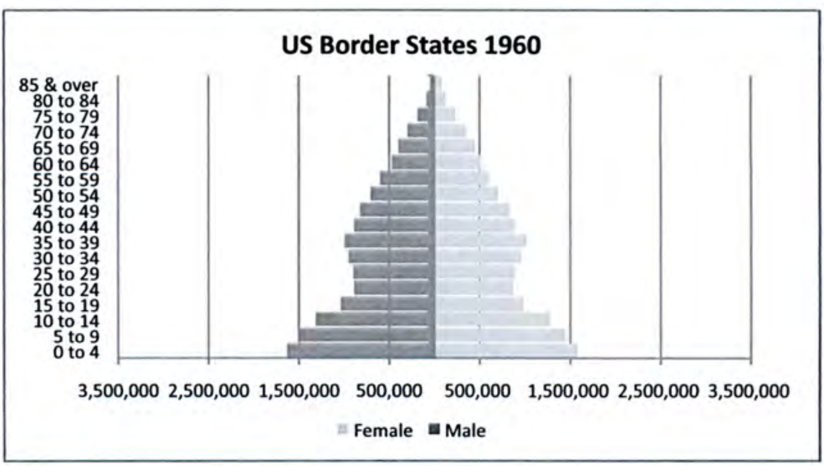
Sources: Medians computed by the author from 5-year-age and sex data; 1960 to 2000 data are from INEGI, Censo de Población y Vivienda, 1960, 1970, 1980, 1990, and 2000; 2010 to 2030 data are from CONAPO (2008) Proyecciones de Población.

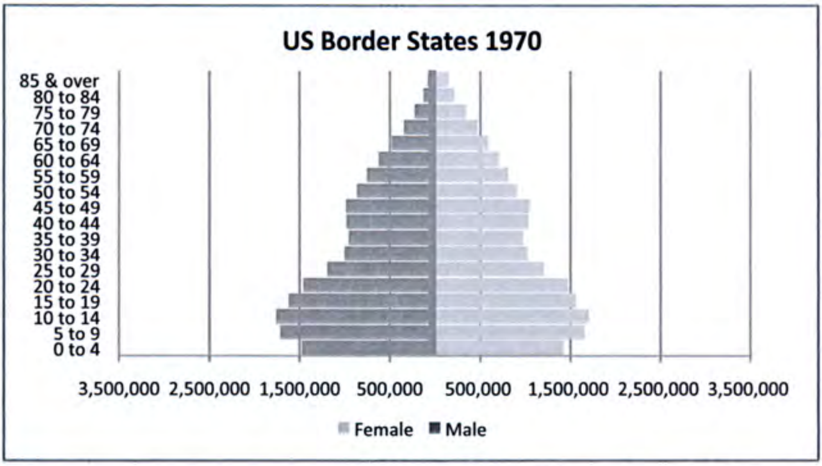
Figure 20. Median Ages for the Populations of the Four U.S. Border States and the U.S., 1950–2030



Source: Author.

Figures 21–28. Age Distribution of the Combined Populations of the U.S. Border States, 1960–2030




US Border States 1970
85 & over
80 to 84
75 to 79
70 to 74
65 to 69
60 to 64
55 to 59
50 to 54
45 to 49
40 to 44
35 to 39
30 to 34
25 to 29
20 to 24
15 to 19
10 to 14
5 to 9
0 to 4
3,500,000 2,500,000 1,500,000 500,000 500,000 1,500,000 2,500,000 3,500,000
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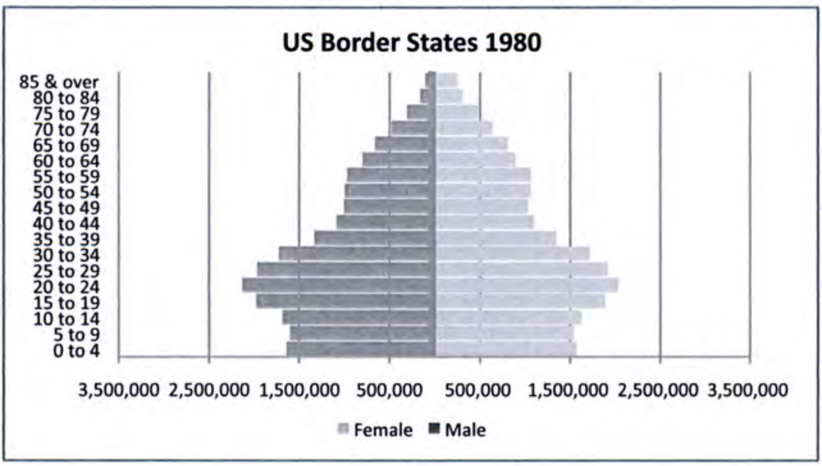
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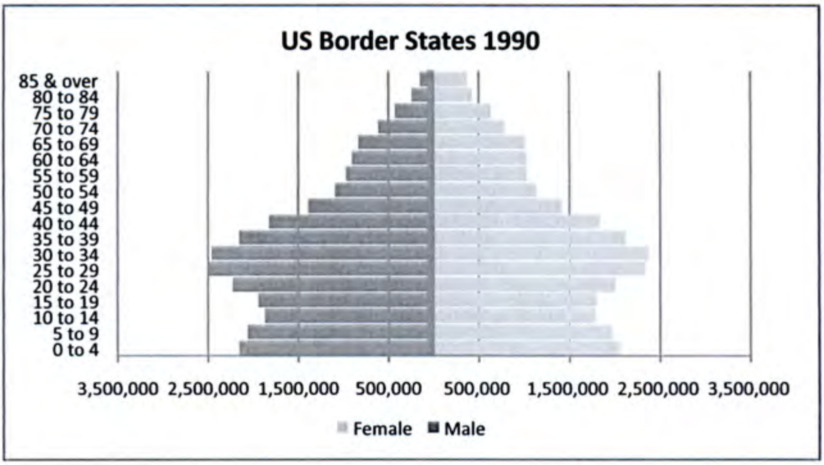
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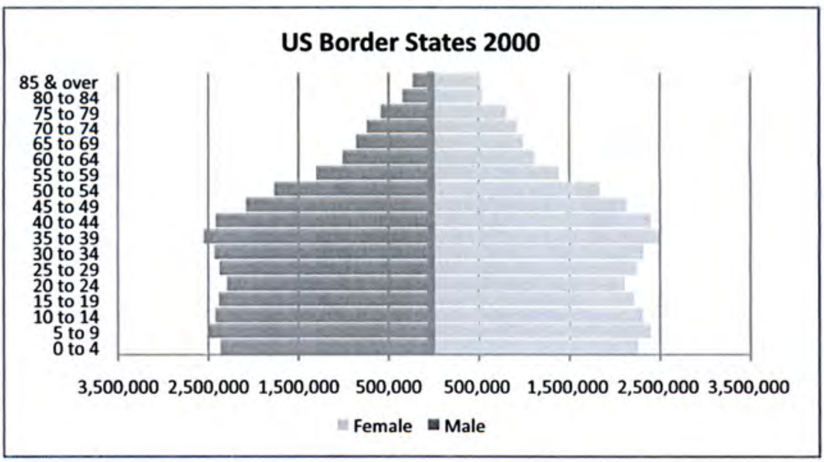
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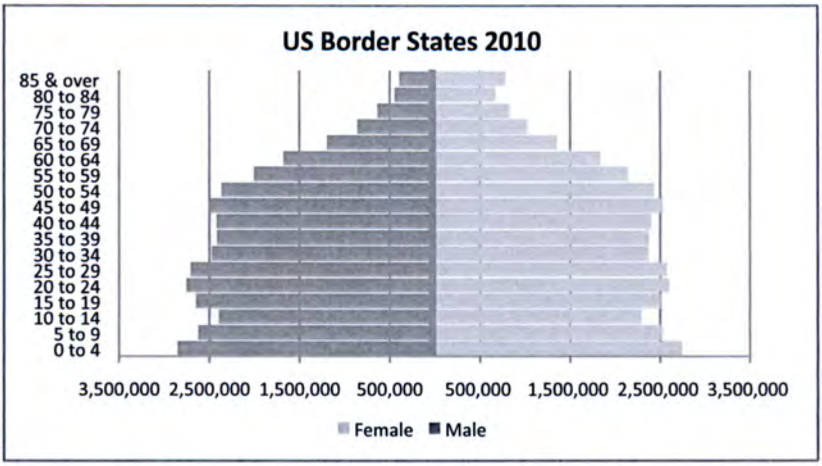
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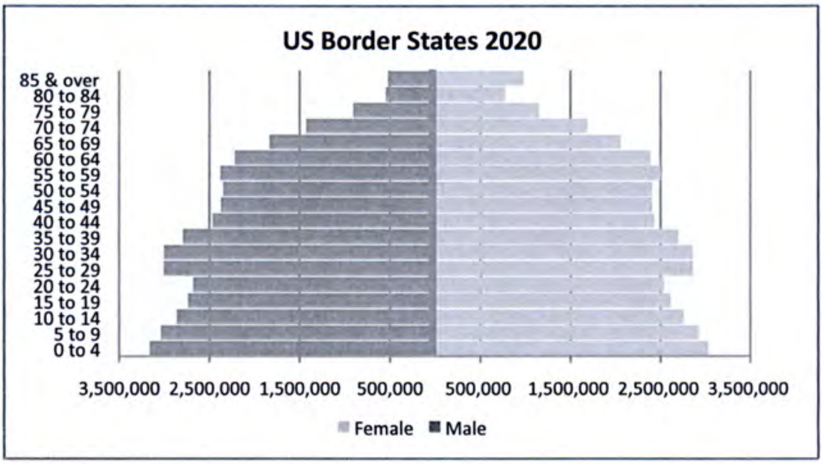
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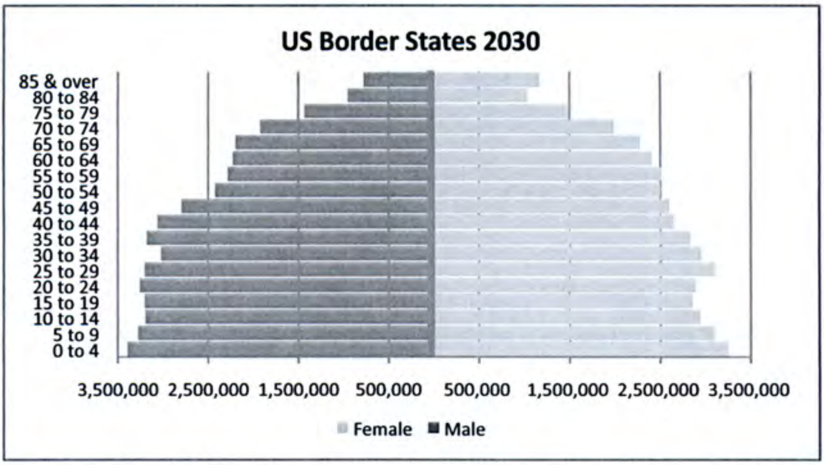


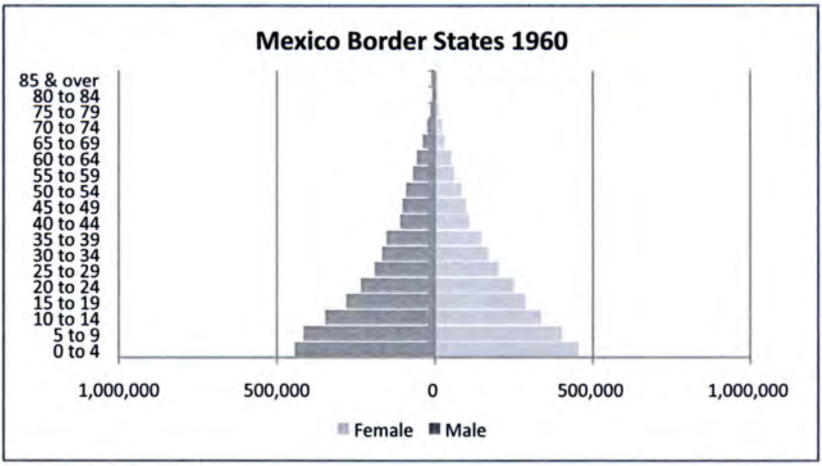
Source: Author.

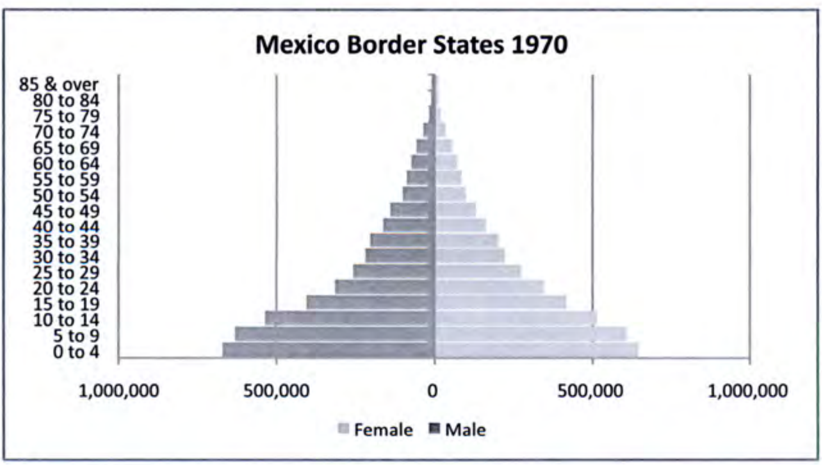
Figures 29 through 36 are population pyramids for the combined Mexican border states. Pyramids are shown at 10-year intervals from 1960 through 2030—the same sequence shown for the U.S. border states in Figures 21 through 28. These figures use the same horizontal axis scale so that both the shape of the age distribution and the growth of the border state's population can be seen over time. In 1960 (Figure 29), the border states' age distribution exhibited the classic pyramid shape (as did Mexico as a whole, see Figures 10 and 11). In 1970 (Figure 30), the border states' age distribution retained its pyramid-like shape, though the growth of the population is apparent.

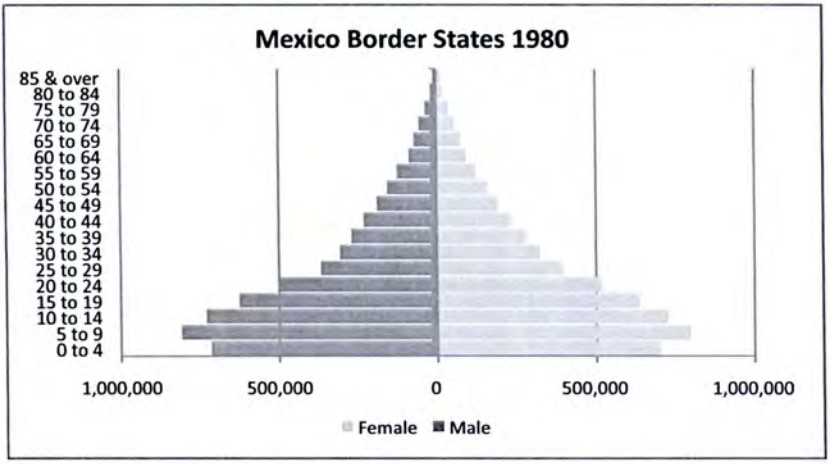
By 1980 (Figure 31), the decrease in fertility that began to occur in the 1970s is visible in the 0-to-4-year-old age cohort. This decrease in fertility is also apparent in the 1990 pyramid shown in Figure 31. By 2000 (Figure 32), the first two age-sex cohorts (0-to-4 and 5-to-9 year olds) are again relatively large. This increase in the first two age cohorts is an echo effect from having large numbers of women in the high fertility years and not an increase in age-specific fertility rates. By 2010 (Figure 33), the youngest age cohort (0-to-4 year olds) is again smaller than the next age cohort (5-to-9 year olds). By 2020 (Figure 35) and 2030 (Figure 36), the aging of the border states' population is obvious.

In 1980, 53.8% of the border states' population was under 20 years old. By 2030, only 27.1% of the border state population is projected to be under the age of 20. During the same time frame, the percentage of the border population 65 years old and older will increase from 3.7% to 10.7%. Figure 37 illustrates the dramatic increase in the percentage of the border-state population 65 years old and older. By 2030, the CONAPO projections indicate that there will be more than 2.5 million people 65 years old and older in the six border states.

Figures 29–36. Age Distribution of the Combined Populations of the Mexican Border States, 1960–2030



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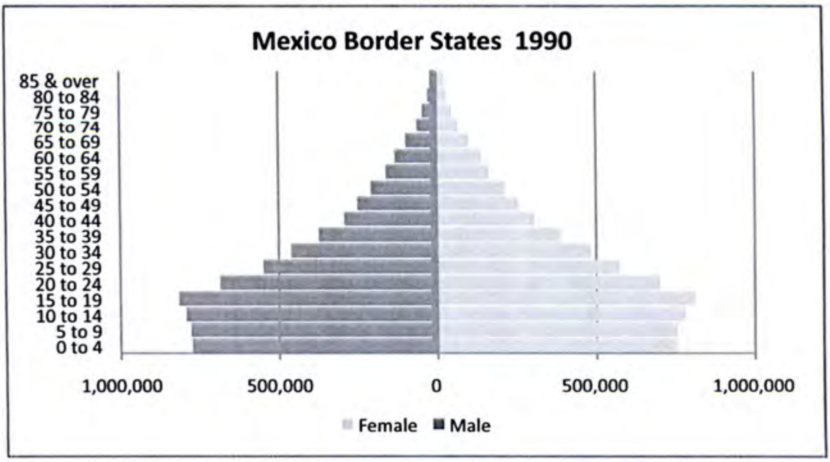
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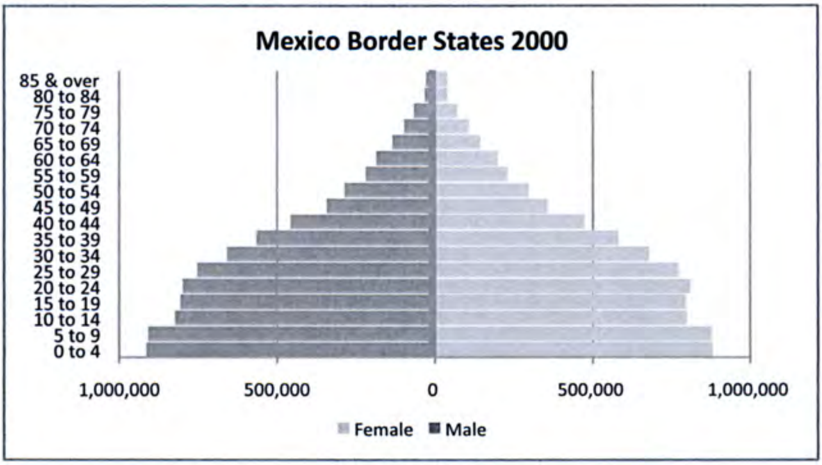
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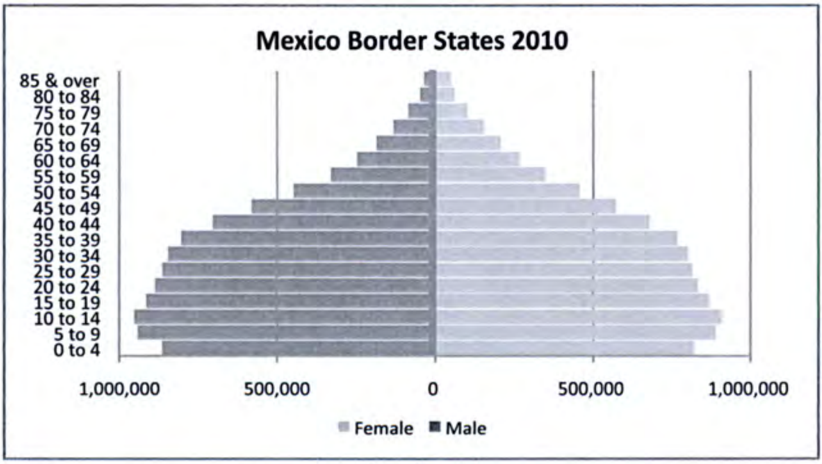
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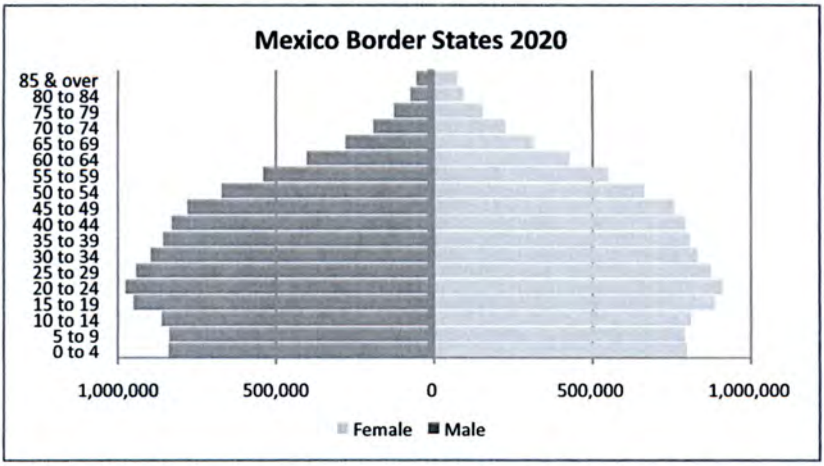
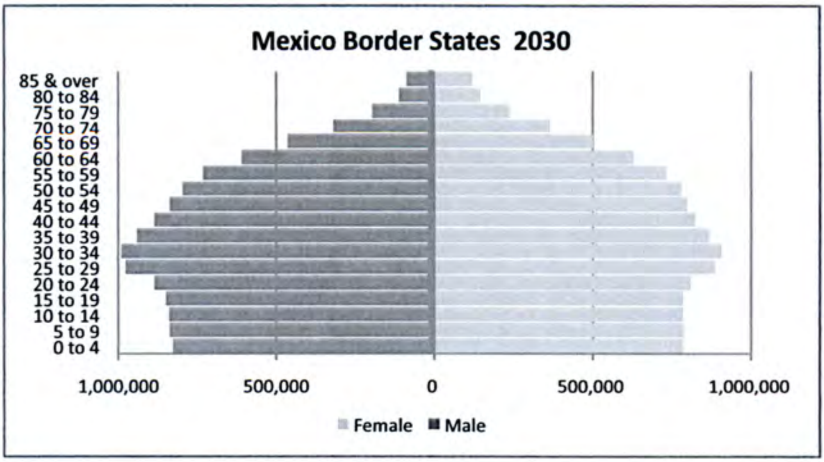
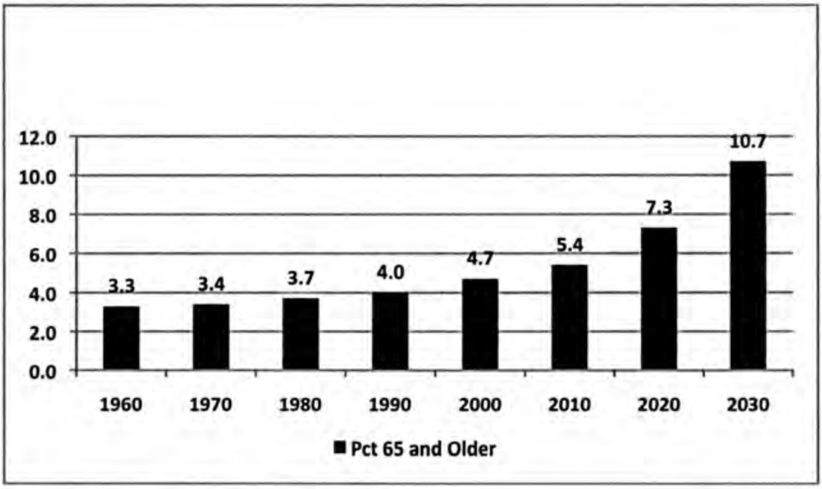




Source: Author.

Figure 37. Percentage of the Population 65 Years Old and Older in Mexico's Border States, 1960–2030



Source: Author.

AGING IN THE BORDER COUNTIES AND *MUNICIPIOS*

As with the two nations and the 10 border states, the population directly adjacent to the border is also aging. Table 3 (U.S.) and Table 4 (Mexico) display median ages in the 10 largest border counties and *municipios* from 1970 to 2005. The 10 largest border counties accounted for 95.6% of the total border county population and the 10 largest *municipios* accounted for 88.6% of the total border *municipio* population in 2005.

In 1970, the 10 largest border counties (U.S.) had a median age of 24.6, lower than either the border states median age (27.3 years) or the nation's median age (28.1 years). The 1970 border county median ages ranged from 21.2 years in Hidalgo County, Texas, to 27.2 years in Pima County, Arizona. By 2000, the 10 largest border counties' median age had increased to 32.2 years—still somewhat below median ages in the border states (33.1 years) and the U.S. (35.3 years). In 2000, seven of the 10 largest border counties had a median age of 30.0 or greater.

Table 3. Median Ages in the 10 Largest U.S. Border Counties

Rank	County	2005 Population	Median Age				
			1970	1980	1990	2000	2005
1	San Diego County	2,931,689	25.4	28.8	30.9	33.2	33.4
2	Pima County	947,533	27.2	29.5	32.8	35.7	36.0
3	El Paso County	709,992	22.7	25.0	27.9	30.0	30.6
4	Hidalgo County	667,154	21.2	24.2	26.1	27.2	27.2
5	Cameron County	371,492	22.2	25.0	27.4	29.0	29.1
6	Webb County	221,165	21.9	23.6	25.5	26.5	26.5
7	Doña Ana County	189,330	22.0	24.8	27.9	30.2	30.4
8	Yuma County	180,009	24.7	27.9	31.2	33.8	34.1
9	Imperial County	153,285	24.0	26.4	28.8	31.0	31.4
10	Cochise County	125,498	24.3	26.8	32.6	36.8	37.8
	Ten Largest	6,497,147	24.6	27.7	30.1	32.0	32.2

Note: Listed by population rank in 2005.

Table 4. Median Ages in the 10 Largest Mexican Border *Municipios*

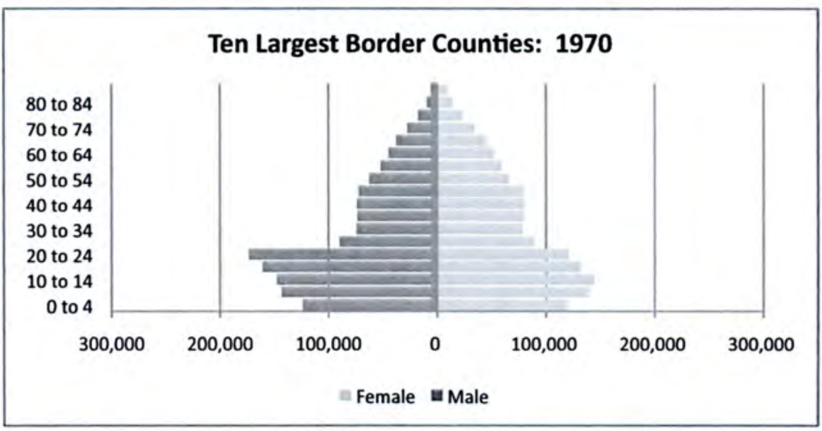
Rank	Municipio	2005 Population	Median Age				
			1970	1980	1990	2000	2005
1	Tijuana	1,410,687	16.7	18.8	21.1	23.3	24.7
2	Juárez	1,313,338	16.8	18.9	21.3	23.4	24.6
3	Mexicali	855,962	16.1	18.7	21.4	24.4	25.9
4	Reynosa	526,888	16.7	18.4	21.3	23.5	24.6
5	Matamoros	462,157	17.1	18.8	21.2	23.4	24.9
6	Nuevo Laredo	355,827	17.3	18.6	21.4	22.6	24.7
7	Nogales	193,517	17.4	19.1	21.0	22.9	24.0
8	San Luis Río Colorado	157,076	15.7	17.5	20.5	23.3	24.9
9	Piedras Negras	143,915	17.7	19.0	21.3	23.2	24.4
10	Acuña	126,238	17.0	17.8	20.1	22.1	23.3
	Ten Largest	5,545,605	16.7	18.7	21.2	23.1	24.8

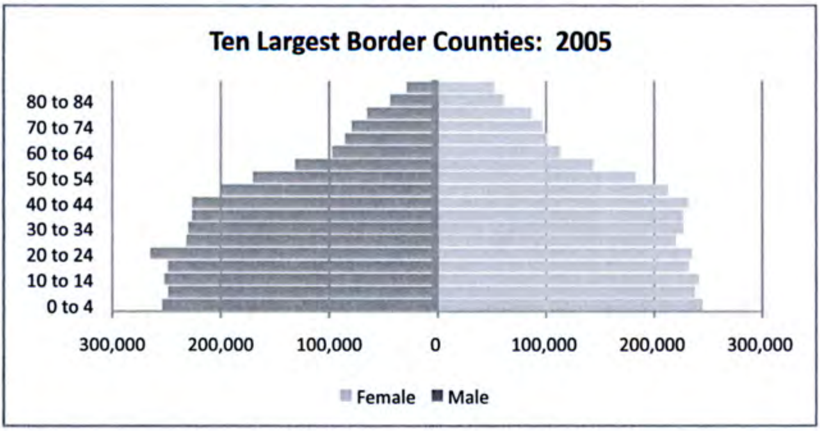
Note: Listed by population rank in 2005.

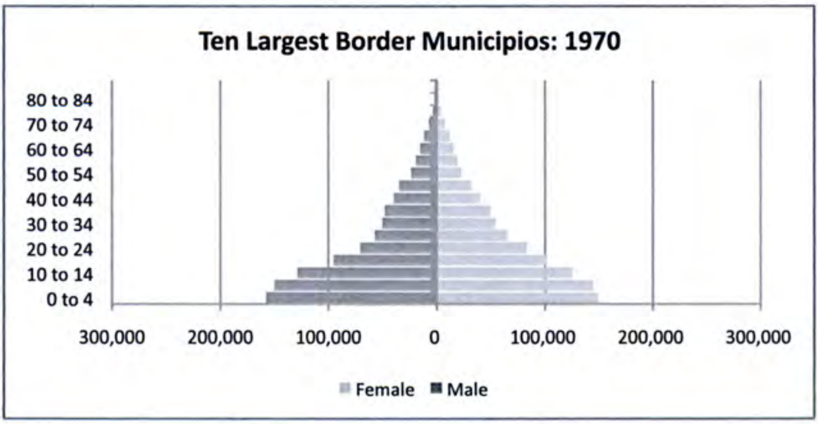
On the Mexican side of the border, the 10 largest *municipios* had a median age of 16.7 years in 1970. While the 1970 median age in the 10 largest *municipios* differed little from the corresponding figure in the border states (16.9 years) and Mexico as a whole (16.6 years), this median was considerably less than in the U.S. border counties (24.6). By 2000, the median age in the 10 largest border *municipios* reached 23.1 years—a figure that remains lower than the 10 largest U.S. border counties (32.2 years), but very similar to Mexico's median age of 23.4 years.

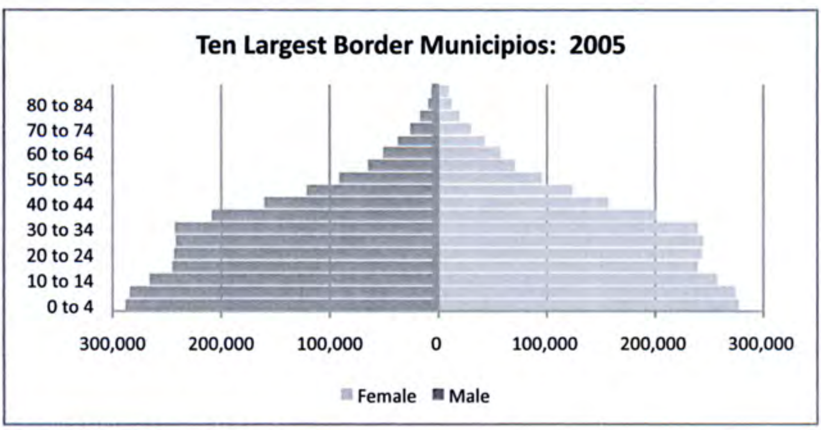
The aging of the border county and *municipio* populations is also apparent in the population pyramids shown in Figures 38 through 41. Figures 38 and 39 illustrate the age distributions of the 10 largest U.S. border counties in 1970 and 2005. Figures 40 and 41 illustrate the age distributions of the 10 largest border *municipios* in 1970 and 2005. The pyramids also suggest that the aging process will continue in the border counties and *municipios*. If past patterns are a reasonable guide to the future, the median age in the U.S. border counties will reach 35 or 36 years by 2030, while the border *municipios* may reach a slightly higher median age—perhaps 36 or 37 by 2030.

Figures 38–41. Age Distribution for the Populations of the 10 Largest U.S. Border Counties and 10 Largest Mexican Border *Municipios*, 1970, 2005









Source: Author.

CONCLUDING REMARKS

In the absence of a major catastrophe (war, epidemic, or the like) or a major and unlikely demographic change, the aging of the border population is a foregone conclusion. The aging process will continue in Mexico and the United States, the border states, and the border counties and *municipios*. An aging border population is built into its current age structure and is reinforced by declining fertility rates, increasing life expectancy, and the likelihood of lower migration rates due to changes in the age structure of migrant sending regions.

Aging of the border population is occurring now and will continue for decades to come. Some of the consequences of border region population aging were described briefly in the introduction. These included the effects of aging on the labor force, the composition of industry, and the demand for goods and services, both public and private. Consider, for example, how different the development of the *maquiladora* industry might have been if the median age of the border *municipios* in the 1970s and 1980s (then 17 or 18 years) had been twice as high.

These and other age-related effects will also change the way we think about transborder interactions, the growth of the border region, and borderland environmental problems. Policymakers can do little to alter the nearly inevitable aging of the border population but they can do a great deal to prepare for its consequences.

First, there is an obvious need for more and better data relating age to economic and environmental issues. Water consumption (and availability), for example, is a critical borderlands issue. Water consumption is almost certainly age related. Families with children are likely to need larger houses and consume more water than older—perhaps retired—people. Age-related changes in the demand for goods and services will also change industrial water use. There are almost no data in either the U.S. or Mexico concerning water consumption by age. Energy consumption, both primary and secondary, is also likely to be age dependent. Again, the need for more and better data in an aging world becomes obvious.

Second, no one needs to be told that economic activity and problems of the environment are strongly linked. An aging population adds to the complexity of these linkages and their policy implications. The recent economic crisis, for example, had different effects on various demographic groups (Engemann and Wall 2010). With or without sophisticated modeling efforts (see next paragraph), policy analysts need to be acutely aware of age-specific impacts of major economic events and economic policy actions.

Third, aging increases the need for increasingly complex and sophisticated economic and environmental modeling of transborder interactions. The border counties and *municipios* are not homogeneous. These areas have different age distributions now and differences will remain even though aging will be a common phenomenon throughout the region. The B20 systems dynamics models have well-developed demographic components—including single year of age and sex cohort-component projection methods. Age and sex distributions within the models are directly linked to the labor force and economic activity and indirectly linked to environmental sectors. The B20 models need to be updated and others need to be built.

Fourth, aging both nationally and in the borderlands will change the political environment that conditions all environmental policymaking. Age is an important determinant of voting behavior—even in the borderlands (Peach and Adkisson 1999).

In short, the aging process occurring nationally and in the borderlands will force all of us to reassess this incredibly dynamic region. This reassessment could lead to imaginative and effective environmental policy and strategy for the borderlands.

ENDNOTES

[1] Unless otherwise noted, the data in this section are from the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2008 Revision*, http://esa.un.org/unpp. January 13, 2010. Figures are constructed by the author. The data are from the UN "medium variant" projections.

[2] Pyramids for each of the four U.S .border states and Mexico's six border states are available on request.

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III

Social Indicators and Measuring Sustainability

Kimberly Collins and Judith Ley García

Introduction to the Project

The objective of this project was to identify the linkages between social indicators and sustainable development in the U.S.-Mexican border region. This information can be used to gauge the likelihood that border communities will incorporate sustainability into planning and future development. To make predictions about sustainability in the border region, researchers considered—in a new way—existing quality-of-life data collected about border region residents from 2005 to 2010.

A critical first step in the process of analysis was to define the meaning of sustainable development for the U.S.-Mexican border region. It is, of course, easiest to look to the definition developed by the World Commission on Environment and Development, for which sustainability is "...thinking about how current residents of a region can meet their needs without compromising the future" (WCED 1987). This sounds reasonable enough, but what does it really mean for the residents in the U.S.-Mexican border region? In a region with biculturalism, binationalism, uniculturalism, migrants, long-term residents, and issues of sovereignty always looming, how do we ascertain whether those living in the region currently are compromising conditions in the region for future residents?[1] Bell and Morse (2003) point out that a useful method for evaluating environmental sustainability of a community is to become familiar with the intricacies of life in the area. This is best done through a systematic analysis of social and cultural data, gathered by surveying people who live in the community. As a result of past efforts to produce quality-of-life information about border region residents, the foundation for making predictions about sustainable development already existed, making the task of identifying the linkages far more manageable within the project's time frame.

This paper begins with an overview of the project and discusses the relationship between quality-of-life analysis and sustainable development. Definitions of the two terms are given in the first section, as well as a description of their application in the border region. This is done by evaluating a few key writings and theories on both topics. As sustainable development and quality of life are related to public policy, the next section of this paper examines the policy problems that are central to the topic. Collectively, this information sets the stage for the analysis of the quality-of-life indicators and their relationship with sustainability. The indicator analysis begins by looking at the border region as a place, defined by objective data and feedback on how residents perceive their city as a place to live. The next set of indicators analyzed is the quality-of-life perception data. A multiple variable analysis is used to ascertain the homogeneity of the region and to identify challenges to sustainable development. The data explored in this paper were chosen from a larger dataset in order to understand the human systems in the border region and capture what sustainability means for the region. The final section of this paper discusses the application of the data to sustainable development, the future possibilities for the border region, and the policies that would improve conditions.

The Connections between Quality of Life and Sustainability in the Border Region

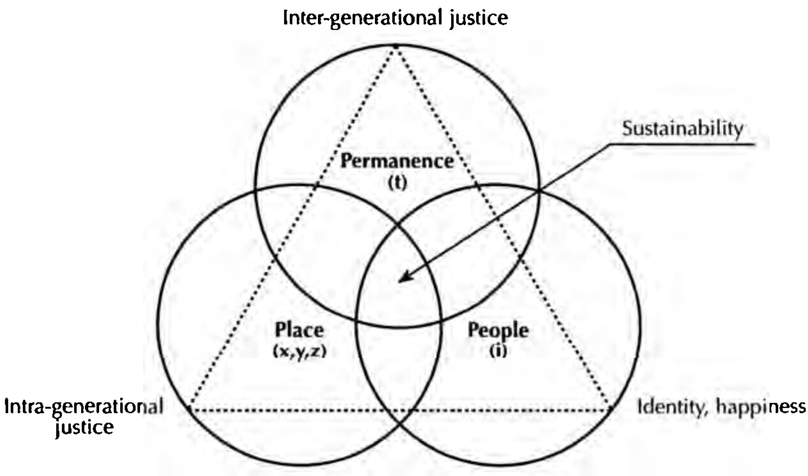
Quality of life as a concept can be interpreted differently by individuals and groups. If you ask a room of individuals what quality of life means to them, a variety of answers will emerge. Individuals place more importance on the issues that are closest to them. Young, single people might consider recreation facilities and nightlife as important components of their quality of life, while those with young children might put more emphasis on educational facilities and the levels of crime in a community. For these reasons, the focus many times is on the place as understood by subjective and objective indicators. Meyer (1987) proposes that quality of life has come to be measured in terms of the "livability" of a community: "quality of life is constructed of shared characteristics residents experience in places (for example, air and water quality, traffic or recreational opportunities), and the subjective evaluations residents make of those conditions."

In order to effectively measure the quality of life experienced by residents of the U.S.-Mexican border region, a longitudinal analysis is required, using both subjective and objective data. The subjective and objective coordinates of quality of life can trace different conditions or levels of livability of places. The method is similar to what has been discussed by theorists (Liu 1976; Dissert and Deller 2000; Szalai and Andrews 1980) as well as practitioners (Morrison Institute). For the current study, 3,686 random sample surveys were collected over a period of four years.[2] The cities included in this study are San Diego and Calexico in California; the Tijuana metropolitan area and Mexicali in Baja California; San Luis-Somerton in Arizona; San Luis Río Colorado in Sonora; El Paso, Texas; and Ciudad Juárez, Chihuahua. The data were collected on a nine-point Likert scale, but this has since been modified to a five-point scale to assist in interpretation.

The connection between sustainable development and quality of life is clear. Sustainable development is seen as a way to improve quality of life (Torjman 2000; Seghezzo 2009). In the same context, measuring quality of life can help to define what sustainability means to a community and develop policies that more adequately address it (Seghezzo 2009; Bell and Morse 2003). Developing sustainably is more likely through an integrated approach to development that considers the totality of the place, including environment, social conditions, economic viability, the people, and issues of permanence. This, of course, stresses the need for cooperation among the governing institutions for policymaking, which, it could be argued, has not been sufficient.

In this paper, the authors have chosen to use Lucas Seghezzo's definition of sustainability, which focuses on place, people, and permanence. As shown in Figure 1, Seghezzo provides the interaction among place, people, and permanence in which sustainability is the common connector.

Figure 1. Sustainability Triangle



Place: the three dimensions of space (x, y, and z); Permanence: the fourth dimension of time (t); People: the fifth, human dimension (i)

Source: Seghezzo 2009.

Place is an important concept in the border region, for it is defined by human activity as well as by the physical location (Masuda and Garvin 2008). Some difficulties experienced by border residents are associated with levels of crime and the lack of trust in police, which are both more particular to the Mexican side, as well as access to public services, government regulation, and cultural identity, which are found on both sides. If we return once again to the categories of Oscar Martinez regarding the "Borderlander," it becomes evident that what makes each category special is how it is related to the place defined as the U.S-Mexican border region. It does not matter if one considers him/herself to be part of only one culture, either U.S. or

Mexican, but it is important to note that the cultural identity is directly tied to the presence of the border. For many residents, there is a clear sense of "the other side."

The idea of permanence is also extremely important in the context of the border region for there has been little discussion regarding the future of the region. The policy conversations generally are not focused on how to improve the common space in the borderlands but on how to correct today's problems or the problems generated by past activities. The conversation is dominated by the need to expand international trade, deal with immigration, address security issues related to drug trafficking and other crimes, and resolve environmental issues.

Domestic concerns and conditions tend to dictate the way in which these policies are formulated, as seen with the focus of U.S. public policy on border enforcement since September 11, 2001, while continuing the trade linkages. Results from these policies can be seen in the border crossing data provided by the Research and Innovative Technology Administration, Bureau of Transportation Statistics (RITA/BTS).

In looking at data for the entire border, in 1995 some 2.86 million trucks and 32.8 million pedestrians crossed north. These numbers changed to 4.4 million trucks and 50.3 million pedestrians in 2002, and to 4.9 million trucks and 44.8 million pedestrians in 2008. Since 2002, the number of trucks has increased, even in a recessionary economy, while the number of pedestrians has decreased (USDOT 2010).

Finally, measuring the happiness of local residents provides insight into their connections with society. Happiness has been related to "autonomy, freedom, achievement, and the development of deep interpersonal relationships" (Seghezzo 2009). Thus, it is important to develop policy for sustainable development that considers the interdependency of environment, economic development, and human needs. Therefore, after a brief discussion of the sources of existing policy problems, this paper analyzes quality of life for those living in the border region by examining conditions using a series of indicators.

What is the Problem that We are Trying to Address?

The U.S.-Mexican border region has experienced tremendous growth over the past 100 years or so. In 1900, there were approximately 350,000 people living along both sides of the border. By the mid-2000s, there were approximately 13.3 million people in the region. As Figure 2 shows, the rate of population growth in U.S. border counties mirrors that of the Mexican municipalities. However, with the San Diego-Tijuana metropolitan region (Figure 3) excluded, the population on the Mexican side of the border surpassed the U.S. side in 1960 and that margin has continued to grow since.

As many people move to and live on either side of the border, it is difficult to track their movement back and forth across the international boundary. Services, commercial activities, and educational opportunities are accessed on both sides of the border. It is not unheard of, for example, for a family to move to the U.S. side of the border so that their children can learn English in the United States and then return to Mexico after their graduation. The point is that some portion of the border population spends time on each side of the border and are binational residents.

The economic pull to the region has come primarily from the Mexican side with the development of assembly plants, or in-bond manufacturing facilities called *maquiladoras*. In 1965, multinational firms began to establish a presence in Mexico's northern border with the implementation of the Mexican Border Industrialization Program (BIP). The BIP was employed in Mexico in part as a method for dealing with a growing unemployed population living along the northern border, which grew exponentially after the United States cancelled the Bracero Program that it had established jointly with Mexico during World War II to increase the number of manual laborers in the United States, particularly agricultural workers. These policy actions were taken in the 1960s, a time when Mexico's population growth began to take off. This scenario is indicative of how policymaking has generally not been coordinated for the border region by the two nations.

Figure 2. U.S. and Mexican Border Counties Population, 1900–2006

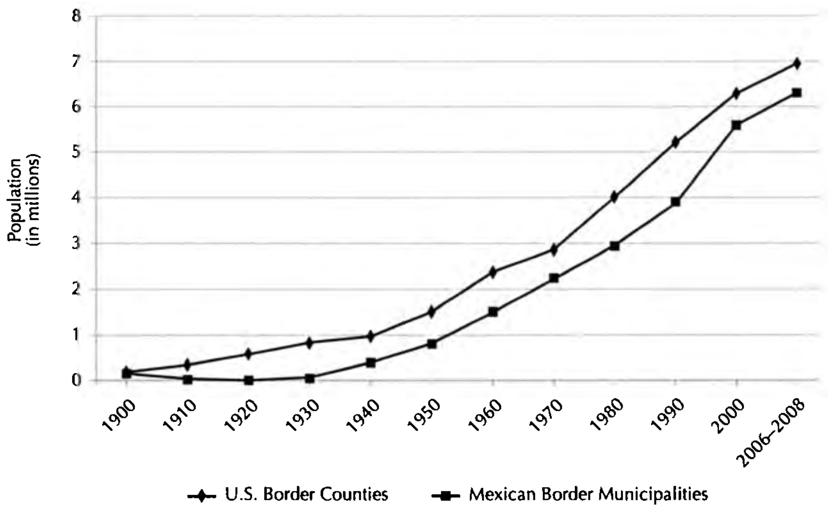
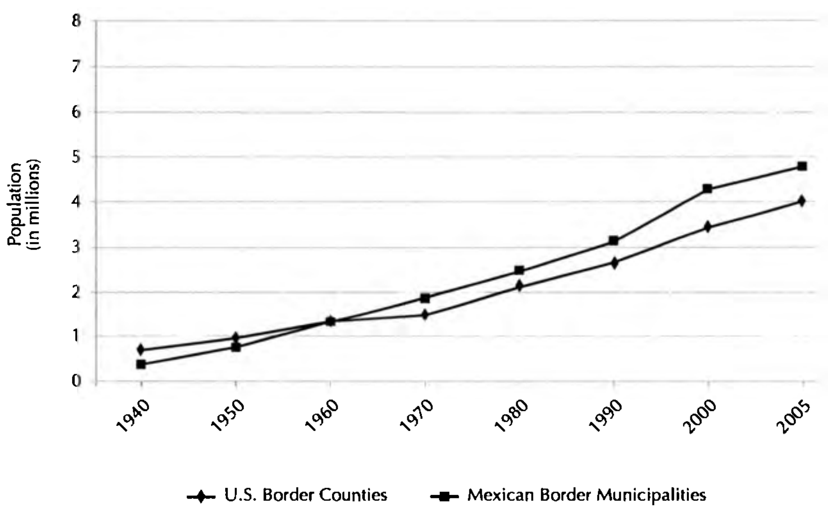


Figure 3. U.S. and Mexican Border Counties Population excluding San Diego and Tijuana, 1940–2006



Policymaking in the border region is usually driven by domestic issues within each nation as seen in the previous example of U.S. security and international trade policies. For Mexico, economic growth and job creation are serious issues for the nation, but are less so in the northern border region. Problems of sovereignty and nationalism in both countries have made it difficult to achieve full binational cooperation on a number of issues. For example, planning and development are major issues that have never been appropriately dealt with in the binational context—though in some communities, the will and the expertise are there. The main inhibitors to action are governmental institutions and financial resources.

Public Policy in the Border Region

There are instances of collaboration between both nations on policies to improve conditions for those living in the region. Through the North American Free Trade Agreement, the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB) were established as binational organizations to invest in wastewater and water infrastructure. From its inception in 1993 through early 2007, the BECC certified 115 projects with a total investment of $2.665 billion (Manning-Gbogbo 2007). The BECC and NADB are not perfect institutions (few are) and there have been real problems with the funding mechanisms developed (as it is generally cheaper for U.S. municipalities to borrow money through bonds rates; in Mexico, municipalities have only recently had the right to borrow funds). But this example shows that when the countries cooperate, there can be real results that improve the individual's quality of life.

When developing public policy solutions to challenges and problems, an intricate understanding of the root cause of an issue is mandatory. If the problem is never truly understood, any policies or plans developed to improve the situation will never really work, as they will never address the real issues. This is a difficult proposition in any situation, more so in a binational region with diverse economies and styles of governance. This does not mean that it is useless to try to improve the lives of those living in the region; it just takes additional time and energy to analyze the situation.

Quality-of-Life Data that Speak to Sustainability in the Border Region

The U.S.-Mexican border as a geographical area is a complex system, with a multitude of interactions among socioeconomic factors, politics, and cultures based in two separate, sovereign nations. This has produced a region with integrated places or cities, with specific livability conditions. Does this mean that the border region has a homogeneous quality of life? Should we consider Mexican and U.S. cities as separate areas in terms of livability from the perspective of residents? One objective of this paper is to analyze the similarities and differences in the responses of surveyed border residents regarding aspects of perceived quality of life and to compare them to what the objective data tell us. The last part of this section will address this issue, but, first, data for the "place" known as the border will be explored.

Returning to Seghezzo's three points—place, people, and permanence—this next section looks at the data collected to understand quality of life in the context of this model. This exercise provides a method for understanding how quality-of-life indicators or social indicators can be helpful in analyzing sustainability in the U.S.-Mexican border region. Place is best analyzed as the individual cities or communities in the region since there are variances within the region. As stated earlier, the cities that are looked at are San Diego (SD) and the metropolitan region of Tijuana, Tecate, and Rosarito (TJ); Calexico (CX) and Mexicali (MX); San Luis-Somerton (AZ) and San Luis Río Colorado (SL); and El Paso (EP) and Ciudad Juárez (CJ). Though it is unfortunate that data for all of the communities in the region are not yet available, the existing sample provides important insights.

To begin looking at place, objective data that describe conditions in different cities along the border and perceptions of individuals living in those cities were analyzed. The data for the following tables were selected from various years during the early 2000s, using data from the U.S. Census Bureau and Mexico's National Institute for Geography and Statistics (Instituto Nacional de Estadística y Geografía–INEGI). Table 1 provides a profile of the communities, including demographics, housing, security, health, poverty, education, and economic features. The percentage of residents that indicated complete satisfaction with living in their city or place is also

Table 1. Comparative Analysis of Social Indicators for Selected Locations along the U.S.-Mexican Border

Social Indicators		SD	TJ	CX	MX	AZ	SL	EP	CJ
Demographic	Annual pop. growth	0.01	0.05	0.03	0.02	0.04	0.03	0.01	0.04
Housing	% Owner occupied	56.67	68.28	54.01	78.34	70.08	76.00	65.18	72.53
Security	# Murder *10,000 res	0.46	0.68	0.00	1.04	0.00	1.40	0.27	0.94
	# Robbery *10,000 res	16.66	20.58	93.80	27.95	1.80	37.05	28.40	10.64
Health	# Doctor *10,000 res	27.80	6.20	8.40	8.00	10.60	4.70	11.20	2.30
	Infant mortality rate per 1,000 live births	5.90	21.30	4.70	20.90	5.30	20.90	4.40	20.70
Well-Being	% Res completely satisfied living in place	0.32	0.29	0.25	0.29	0.55	0.37	0.34	0.290
Poverty	% Res under pov line	11.00	7.20	19.50	10.30	17.60	41.10	22.20	33.40
Education	High school % (25 +)	85.10	29.20	63.00	31.30	72.10	23.80	70.30	25.50
	Higher education (25 +)	33.80	14.10	11.20	17.70	12.60	10.70	18.90	13.90
Economic	Per capita GSP (dis)	47,688.00	8281.00	20,207.00	11,855.00	20,652.00	10,152.00	28,694.00	12,970.30

Note: The data are for varying years during the first decade of the 2000s.
Sources: U.S. Census Bureau, American Community Survey; INEGI Censo 2000 and 2005; U.S. Department of Justice, FBI; Pan American Health Orgranization; Consejo Nacional de Población; QoL survey; U.S. Department of Commerce.

provided. Table 2 converts these data into a five-point scale, with one being the lowest and five the highest. As seen in this second table, San Diego consistently ranks the highest of all of the cities surveyed. The issues in this city were population growth, housing, security, and well-being, or the percentage of individuals completely satisfied with living in the place. In comparison, Ciudad Juárez had the lowest rankings for all of the categories analyzed.

The U.S. communities generally had higher rankings than their Mexican counterparts, but the greatest disparities were found among the U.S. cities, with the Mexican communities being fairly homogeneous. This is an interesting indicator for assessing the border communities' homogeneity. The variances are greater on the U.S. side of the border with an 18-point difference between San Diego and Calexico. On the Mexican side of the border, the difference between the communities was only six points, found between Ciudad Juárez (21 points) and Mexicali (27 points). These data say a lot regarding the focus of domestic policies in the United States and Mexico. In the United States, quality of life and community/economic development vary greatly among communities. In Mexico, quality of life and community/economic development are more consistent among the cities analyzed here, which can be attributed to the economic growth policies implemented by the government.

The next area of exploration regarding quality of life in border region communities involved collecting data on the perceptions of residents. As discussed previously, a nine-point Likert scale was used in the main survey framework, making it possible to use quantitative methods to analyze qualitative data. Again, an important consideration for this analysis is to understand the homogeneity of the region. Therefore, a multiple correspondence analysis[3] (MCA) was applied, allowing for the exploration of multiple categorical variables and to distinguish the various typologies of border residents' perceptions. In conducting this analysis, the data were transferred to a five-point scale, using categories equivalent to excellent, good, medium, poor, and very poor.

Figure 4 shows that responses fall into six different typologies. The first is the "worried" border resident (12.80% of total), in which 82.57% of this group has a lot of trouble sleeping, feels unhappy, or is depressed very often, and the cost of housing is a great burden for them.

Table 2. Five-Point Comparative Analysis of Social Indicators for Selected Locations along the U.S.-Mexican Border

Social Indicators		SD	TJ	CX	MX	AZ	SL	EP	CJ
Demographic	Annual pop. growth	5	1	3	4	2	3	5	2
Housing	% Owner occupied	1	3	1	5	4	5	3	4
Security	# Murder *10,000 res	4	3	5	2	5	1	5	2
	# Robbery *10,000 res	5	4	1	4	5	4	4	5
Health	# Doctor *10,000 res	5	1	2	2	2	1	2	1
	Infant mortality rate per 1,000 live births	5	1	5	1	5	1	5	1
Well-Being	% Res completely satisfied living in place	2	1	1	1	5	3	2	1
Poverty	% Res under pov line	5	5	4	4	4	1	3	2
Education	High school % (25 +)	5	1	4	1	4	1	4	1
	Higher education (25 +)	5	1	1	2	1	1	2	1
Economic	Per capita GSP (dis)	5	1	2	1	2	1	3	1
Total		47	22	29	27	39	22	38	21

Source: Authors' calculations from Table 1.

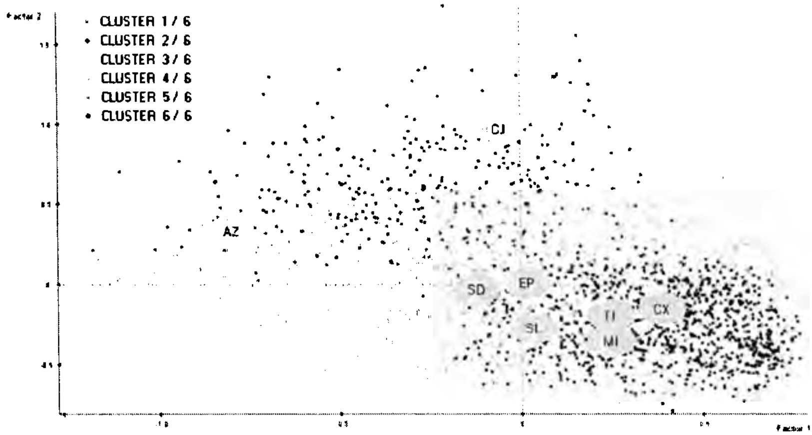
Yet, they are completely satisfied with city services (parks, fire department, trash collection, street lighting) and feel completely satisfied living in the city and the life they live. This group is considered "worried" because the cost of living (particularly housing) is of great concern for them. The residents of San Luis-Somerton (72.33% of respondents in this city), Ciudad Juárez (36.78% of respondents in this city), and El Paso (38.27% of respondents in this city) fall into this category.

The second group is categorized as "everything is wrong." This group consists of 8.49% of total responses. The issues experienced by those in this category include inadequate health care services (facilities and physicians); low satisfaction with government services; high concern about air quality and its impact on health; rapidly increasing cost of living; significantly burdensome housing costs; trouble sleeping; feeling very unsafe walking in their neighborhoods; poor conditions for raising children; and general dissatisfaction with living in the city. Residents in Ciudad Juárez (16.35% of respondents in this city) and in San Luis Río Colorado (13.07% of respondents from this city) were found in this grouping. These residents are very unsatisfied with their city and their lives.

The third category is "everything is wonderful, but it is getting more expensive." One-third of both the San Diego (33.37%) and San Luis Río Colorado (30.65%) residents surveyed fell into this group. A total of 18.04% of all respondents in the border communities surveyed fell into this category. The individuals in this group are happy with the health services, housing, and the city, and are completely happy with their lives. They are not concerned with the quality of the air or its impact on them and most were long-term residents (80.48% have lived in the city nine years or more). They are currently satisfied with the housing costs, but feel that cost of living is becoming very expensive.

The fourth category is "in the middle." This includes 17.21% of total respondents surveyed, who are found mainly in Tijuana (22.49% of respondents in this city) and Ciudad Juárez (27.40% in this city). These residents are in the middle, as they are not really satisfied nor dissatisfied with their lives. They are not satisfied with city services and do not trust the local police departments. They are moderately concerned about the current economic situation, cost of housing, and effects of air and water quality on their health. In regard to their satisfaction with living in the city and personal quality of life, they are

Figure 4. Typology of Responses and Projection of Cities in Quality of Life Responses of Select U.S.-Mexican Border Cities



Source: Authors' calculations.

in the middle—neither satisfied nor dissatisfied. They are also in the middle about the city being a good place to raise children and regard the people living in the city as unfriendly.

The next category includes mainly respondents from Tijuana (49.70% of residents and 17.46% of total respondents) and is titled "good, but the government is failing." People in this category are generally completely happy, do not have any problems sleeping, are rarely depressed, enjoy their activities, and are satisfied with their lives. Their economic situation and the availability of jobs are getting better, but the cost of living is getting more expensive. A few were concerned with air and water contamination, but they are generally satisfied with living in the city, as there is access to good health care facilities and doctors as well as adequate trash collection, street lights, parks, schools, firefighting services, and piped water. However, this group also reported feeling very unsafe with crime in their neighborhoods, distrusting the police, and being concerned by traffic congestion as problems, leading to a general dissatisfaction with the local government.

The sixth category accounts for 26% of the total respondents and is classified as "everything is good." The respondents in this category are in San Diego (37.93% of residents surveyed), San Luis Río Colorado (47.49% of residents), Mexicali (47.70%), and Calexico (47.42%). It is the largest category and the most diverse. These residents enjoy their lives and the city they live in. They are completely satisfied with city services, the economic situation is good, housing costs are not really a burden for them, and they are not concerned about crime. It is interesting to look at this large group of respondents in comparison to the rankings of the border region as found in Tables 1 and 2. There is a definite disconnect between residents' perceptions and what the data say about the border region as a place. At this point, more data collection and analyses need to be carried out to better ascertain why this difference exists.

What does this categorization and its analysis say about the border region as a whole? Obviously, it is not a homogeneous region from the perspective of residents, since there are six different categories in which the opinions of the residents vary greatly. Particular problems in the border region are related specifically to cities or subregions and need to be addressed as such, instead of through broad, general policies that look at the border as a whole. Considering the current policymaking framework in the region, this suggestion is even more ambitious than the general call for more consistency and coordination in policymaking by the United States and Mexico.

Future Prospects and Where We Need to Go from Here

Permanence is an important component in the discussion of sustainability of a region. It draws attention to the importance of understanding how policy decisions made today will impact the lives of future residents of the region. When looking at past policies and programs and the condition of border cities today, clearly there is room for improvement. If population growth continues at similar rates and increases the burden on existing infrastructure, it is likely that this infrastructure will not have the capacity to support the needs of the growing population. Quality of life in the border region will deteriorate for lack of collaborative improvement plans and binational investment in border infrastructure. Therefore, policies need to be made today to avoid generating quality-of-life issues in the future. Ciudad Juárez and Tijuana serve as useful examples of how the entire border could be in the future, because both of these cities have experienced significant population growth and have high rates of crime, insufficient infrastructure, and the most dissatisfaction from residents. San Luis Río Colorado can also be grouped in this example, but on a much smaller scale.

It is useful to view border communities collectively, as a system, when developing joint policies designed not only to resolve current issues, but also to address issues associated with future population growth. This is a system that is made up of a number of subsystems (communities) that need specific attention to address the local issues. As demonstrated by the data, quality of life experienced by border region residents is not homogeneous, but by improving understanding of the intricacies within each community and the interactions between them, better policies can be made.

If the "place" known as the border region is better understood, and policies affecting the border region are coordinated binationally and cohesively, then quality of life and the likelihood of developing sustainably in the future will increase. This is seen with the programs that were implemented by the BECC and NADB to improve water quality in the border region. More agencies that can implement policies and programs to address a broader spectrum of issues (rather than singling out environmental challenges, for example) should be established. Regional and local leaders should come together to identify common challenges and to develop a new vision for economic development. Once this groundwork has been laid, methods for addressing obstacles (both in practical and ideal terms) should be outlined, as well as a plan for achieving the vision for development. Economic development needs to take both the global and local contexts into consideration. It cannot be stressed enough that the communities along the border are affected by policies made and actions taken in both countries—by the individual governments—to respond to the myriad of challenges the region faces. Unfortunately, policymaking has not been done comprehensively nor consistently. It is likely that many of the problems are the result of negative externalities of market forces and government policies. The obvious response, then, is that the community members, government, and other stakeholders should work together to improve the conditions for those living in the region today and tomorrow.

ENDNOTES

[1] For more information on the classification of border residents and crossers, see Paul Ganster and David E. Lorey's book *The U.S.-Mexican Border into the Twenty-First Century,* 2nd ed. Ganster and Lorey provide a clear, concise overview of these classifications based upon Oscar Martinez's work.
[2] The quality-of-life data collected for this paper was done in collaboration with a number of colleagues from many different border research institutions. In particular, Sergio Peña at El Colegio de la Frontera Norte, Ciudad Juárez; Paul Ganster at San Diego State University, and colleagues at Arizona State University, Subhrajit Guhathkurta, Edward Sedalla, and David Pijawka. The research was funded through the Southwest Consortium for Environmental Research and Policy as part of the U.S. EPA's work in the border region.
[3] A multiple correspondence analysis is a descriptive/exploratory technique designed to analyze multivariable tables containing some measure of correlation between rows and columns. The results provide information that explores the structure of categorical variables and assigns coordinates to relate the different categories to each other—based on the distance between them—to construct typologies of groups of individual who have similar answers (see Moscoloni 2005).

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IV

Environmental Sustainability Policies and Practices on the Mexico-Texas Border

José Luis Castro-Ruiz and María Eugenia González-Ávila

ABSTRACT

The concept of sustainability is currently found in all areas of public policy, from the local to global levels, within the framework of principles and objectives of multiple international institutions, and in nongovernmental agencies as well as the private sector. This extensive recognition of sustainability's importance at the conceptual level contrasts with the difficulties presented by its practical application in the field. This paper addresses the relationship between the theory and practice of sustainability at the U.S-Mexican border, a region whose conditions of urban and economic growth have historically created very complex environmental issues. However, the region has addressed the subject through agreements and binational programs signed over the last two decades as well as through initiatives developed in each country at the state and local levels. Focusing on the case study of the Mexico-Texas border, we examine the evolution of environmental sustainability at the subnational level both within legislative frameworks as well as in state-level regional planning mechanisms on both sides of the border. The objective is to reflect on the current level of information and knowledge of border environmental challenges and the growing demand for deeper coordination with binational institutions that address common environmental issues.

INTRODUCTION

Since its formalization as a concept, sustainability[1] has permeated governmental policies from the local to global levels. It also has developed into an integral part of the principles and objectives of multiple international institutions, nongovernmental organizations, and the private sector. The U.S.-Mexican border region has undergone significant institutional development in regard to the management and preservation of its natural resources. Both countries currently include the principles of sustainability as part of their environmental policies.

A key issue regarding the evolution of the concept of sustainability within binational institutions is its application at the subnational level on each side of the border. This is important because, to the extent that the local and state planning initiatives synergize with binational institutions in terms of their sustainability practices, the better the different levels of government can coordinate their efforts. Governments will be able to more efficiently orient their own programs and actions in favor of the environment and natural resources. In this sense, it is reasonable to assume that there are notable differences in planning throughout the border region. These differences are a product of the contrasting political, economic, social, and cultural characteristics of the U.S. and Mexico.

This paper addresses the relationship between environmental sustainability theory and practice[2] in the United States-Mexican border region at the subnational level, focusing on Mexico and Texas. Our objective is to analyze the evolution of the integration of sustainability provisions in the current planning mechanisms and policies at the state and regional levels. The goal is to understand the real progress made by different entities involved in planning at such levels, and the long-term expectations that may materialize under those scenarios. The paper consists of four sections. The first is a brief introduction regarding the theory of sustainability. The second section examines environmental policies in Mexico and Texas from a comparative standpoint and also looks at the historic evolution of emerging problems and the integration of environmental sustainability principles.

The third section analyzes a sample of the subnational plans on each side of the border for the last decade. We conclude with reflections on the implications for long-term planning.

From Stockholm to Rio: A Brief History of Sustainability Theory

A precursor of what would later become the concept of sustainability and then sustainable development was the thesis of *the physical limits to population and economic growth,* part of the economic theory of Thomas Robert Malthus in 1798. It states that development in a geometric or exponential progression of the population and of food production would tend to be arithmetic or linear. This would result in insufficient food and wages below subsistence levels; thus, Malthus suggested that the solution would be to reduce birthrates.

In 1817, David Ricardo addressed the planet's limited capacity and the law of diminishing returns, which would make more work and capital necessary as well as lower-paying jobs, reaching subsistence levels. He came to the same conclusion as Malthus on the need for population control. However, it should be noted that both authors were more concerned about social pressure regarding the distribution of wealth and food, as well as the availability of capital, than environmental exploitation as another factor to care for or consider.

During the1970s, the environmental crisis became evident, and this was reflected in the works of authors such as Kenneth E. Boulding and Paul and Anne Ehrlich. In addition, *The Limits to Growth* was published by Meadows et al. (1972). These authors stressed the need for a reduction in American growth, which was supported by Boulding's essay titled "The Economics of the Coming Spaceship Earth," published in 1966. Paul Ehrlich, a biology professor, would subsequently have a decisive and influential role in regard to the topic of zero growth upon publishing *The Population Bomb* in 1968. Two years later, along with Anne H. Ehrlich, *Population, Resources, Environment* was published. The document raised the need for limiting and stabilizing the population through a policy of population control (Tamames 1977).

In *A Blueprint for Survival* (1972), Edward Goldsmith and several British scientists performed numerous tests on ecological problems and indicated that the world cannot confront continuous and increasing ecological demand nor can it be sustained indefinitely. For this reason it was necessary to reach a "stable society," which causes minimal disturbance to ecological processes, conserves the maximum amount of raw materials and energy, and maintains a stable population and social system (Tamames 1977). The Club of Rome, which broached the topic in *The Limits to Growth* in 1972, was key in promoting the research findings of *The Blueprint for Survival.*

During the 1980s, the topic of growth and the environment was addressed again within the United Nations (UN) declaration approved in Stockholm. This would become the precedent for what is now understood as sustainable development. The UN would later consolidate this concept in 1987 with the World Commission on Environment and Development (WCED) report, *Our Common Future*, which is also known as the Brundtland Report. This document discussed the idea of development and the environment in such a manner that it would later be impossible to separate the concepts. The report advanced the view that development cannot be maintained if the base for environmental resources is deteriorated (WCED 1991).

It is important to note that the Brundtland Report does not go into specifics regarding zero growth. On the contrary, the report indicates that growth is needed in order to overcome poverty, even though it recognizes the differences between rich and poor countries. The report also recommends that rich countries seek out clean technologies and that poor countries grow, with wealthy countries simultaneously aiding poor countries (Pierri 2006). In addition, the report does not distinguish between growth and development, but rather assumes that both are equally important, interdependent, and not opposed to the other (UN 1971).

Authors such as Lélé emphasize that the term *sustainable development* assumed new importance in 1980, when the International Union for Conservation of Nature (IUCN) presented the World Conservation Strategy (WCS). The strategy emphasized that sustainable development was a key objective that could be achieved through the conservation of natural resources (Lélé 1991). The strategy was prepared with funds from the UN Environmental Programme and the World Wildlife Fund (WWF). It was published in 1980 and presented to FAO and UNESCO, where it is regarded as the culmination of over two decades of conservationist thought, particularly from the UICN. The strategy indicated that conservation should reach a global scale and offered a conceptual framework and a practical guide.

In addition to the WCS, other events would strengthen the idea of sustainable development. Examples include the Report of the North-South Commission (1981), the Proclamation of the Letter from the United Nations for Nature (1982), and the World Industry Conference on Environmental Management (1984). These were followed by the Conference on Conservation and Development organized by UICN-UNEP-WWF in Ottawa (1986), in which the need for a type of sustainable and fair development was ratified, and where conservation would take a decisive role in the growth of the countries, considering all people and ways of life that are linked to the environment (Sadler 1994; Lélé 1991). Thus, the WCS played an important role in linking antidevelopment zero growth conservationism from the 1970s and reconsidering issues regarding growth and conservation from the 1987 Brundtland Report under the overall objective of sustainable development.

The 1992 WCED conference in Rio de Janeiro sought to implement sustainable development on a global scale through legal commitments linking governments with clear financial resources and strategies. This led to the approval of five documents: (1) The Rio Declaration on Environment and Development; (2) Agenda 21; (3) the United Nations Framework Convention on Climate Change; (4) the U.N. Convention on Biological Diversity; and (5) the Statement of Forest Principles. However, the most powerful countries, including the United States, did not commit any financial resources nor did they approve the Declaration. This was a setback after the advances made in Stockholm in 1972 and did not address key topics such as external debt of the poorer countries, toxic waste, and nuclear energy (Guimarães 1992: 90–100). Also unaddressed were concepts such as paying for long-term environmental damage, limiting resource use, or developing countries' environmental efforts. In summary, the process of evolution toward the concept of sustainable development has involved different socioeconomic and environmental events whose importance and connectivity have been understood by international organizations, with the ultimate objective of achieving human growth that does not harm its source of origin.

Sustainability within the Framework of Subnational Institutions

One of the main agreements that resulted from the 1992 Rio meeting was the adoption of Agenda 21, which had been in preparation since 1989. The program consists of actions agreed upon by participating countries to be applied locally, nationally, and globally by governments, organizations, and different groups in all areas in which human activities affect the environment. The need to integrate the principles of sustainable development within national policies and programs for environmental protection was reaffirmed once again at the Millennium Summit held in 2000.

The results of this entire process up until now at a practical level have been different in each case. For example, these results have been influenced—among other factors—by the political-administrative systems and development priorities of Mexico and the United States.

Two entirely different and unequal governmental systems meet at the U.S.-Mexican border, and these systems' characteristics have influenced environmental policy and institutions in the two countries. The U.S. political structure rests on a federal agreement based on the Constitution, and the federal and state governments divide their power on different issues. With respect to environmental policies, the U.S. model is very fragmented. While the Environmental Protection Agency (EPA) is the principal authority in regard to the environment, there is a considerable number of federal agencies with authority over various environmental areas. There are also equivalent state and local environmental agencies.

The political structure of Mexico is basically centralized, notwithstanding the constitutional modifications and municipal reform of 1983. Legislative guidelines on environmental matters are stated in the General Law on Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente–LGEEPA), which also outlines implementation for the Ministry of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT). In line with this centralized system, states and municipalities issue their own legislative regulations, which are basically duplicates of the federal frameworks and in certain cases establish guidelines in order to address specific regional problems.[3]

Federal and State Levels in the United States

The aforementioned systems define a group of environmental institutions that converge along the border between Mexico and Texas, which differ in chronology and structures. Table 1 shows the historic evolution of these institutions and compares them to the binational institutional frameworks. One observation, which immediately arises, is the difference of the historic development of institutions on each side of the border. The current U.S. environmental policy has a long tradition that traces its roots to the 19th- and early 20th-century conservationist movement associated with figures such as President Theodore Roosevelt, under whom the Forest Service was created, and John Muir, founder of the Sierra Club. This period witnessed early efforts on environmental legislation such as the Refuse Act, a federal statute that formed part of the Rivers and Harbors Act of 1899 and which prohibits the disposal of trash in navigable waters without a permit (Table 1).

During this period, water was seen as an essential condition of development. This was reflected in the Reclamation Act of 1902, which promoted financing of irrigation projects in the western U.S. The 1940s witnessed the introduction of the first legislation to promote intergovernmental programs to eliminate or reduce contamination in surface or groundwaters. The design of what is currently U.S. environmental policy coincided with the environmental movement of the 1960s,[4] whose principles included the conservation and restoration of natural resources, the preservation of wildlife, reduction of pollution, and improvement of urban life. This period (1960–1980) witnessed the introduction of the most emblematic federal environmental initiatives, including the Clean Water Act, the Clean Air Act, and the National Environmental Policy Act (NEPA) of 1969,[5] as well as the founding of the Environmental Protection Agency in 1970, which integrated and consolidated different environmental programs from other federal agencies.

Texas environmental institutions have a long history related to a strong need to regulate access to water resources. The first legislative initiative, the 1913 Irrigation Act, created the Texas Board of Water Engineers (TBWE) to determine surface waters rights. The institution gradually evolved toward the protection of water and air in the middle of last century and moved into areas such as toxic and non-toxic waste in the following decades.[6]

During the 1990s, Texas legislation looked to make the protection of natural resources more efficient through the consolidation of different programs. These efforts culminated with the creation of the Texas Natural Resource Conservation Commission (TNRCC) in 1993, which integrated the roles of the Texas Water Commission and the Texas Air Control Board. In 2002, the TNRCC became the current Texas Commission on Environmental Quality (TCEQ), integrating statewide functions in a similar manner to the U.S. EPA (www.tceq.state.tx.us).[7]

Table 1. Mexico-Texas Border: Timeline of Environmental Institutional Development

Decade	Mexico	Mexican Border States	USA	Texas
1620	• Sanitary Court, 1628			
1890			• River and Harbors Act (Refuse Act), 1899	
1900			• Reclamation Act, 1902 • U.S. Reclamation Service, 1902 (Bureau of Reclamation, 1907)	
1910	• Department of Population Health		• Migratory Bird Treaty Act, 1918	• Irrigation Act, 1913 • Texas Board of Water Engineers (TBWE), 1913 • Legislation for the creation of clean water supply districts, 1919
1920	• Federal Law of Irrigation Waters, 1926 • National Commission of Irrigation, 1926 • Water Law, 1929			• Legislation for the creation of water improvement and control districts, 1925 • Brazos River Authority, 1929
1930	• Water Law of National Ownership, 1934			• Texas State Soil and Water Conservation Board (TSSWCB), 1939

Table 1. *(continued)*

Decade	Mexico	Mexican Border States	USA	Texas
1940	• Conservation Law of Land and Water, 1945 • Irrigation Law, 1946 • Ministry of Hydraulic Resources (Secretaría de Recursos Hidráulicos–SRH), 1947 • Federal Law of Sanitary Engineering, 1948		• Federal Water Pollution Control Act, 1948	• Legislation regarding the standards of drinking water for public supply systems, 1945 • Legislation that establishes the private nature of groundwaters, 1949 • Legislation for the creation of groundwater conservation districts, 1949
1950	• Governing Law of the Fifth Paragraph of Constitutional Article 27 Regarding Groundwater, 1956	• NUEVO LEÓN: Law of Water and Sewage Services of Monterrey, 1956 (last reform: 2007)	• Air Pollution Control Act, 1955	• Texas Water Pollution Control Advisory Council, 1953 • Texas Water Development Board, 1957
1960			• Clean Air Act, 1963 (modified in 1977 and 1990) • Solid Waste Disposal Act, 1965 • Water Quality Act, 1965 • Air Quality Act, 1967 • National Environmental Policy Act, 1969	• Texas Pollution Control Act, 1961 • Texas Water Pollution Board, 1961 • Texas Water Commission, 1962 • Texas Clean Air Act, 1965 • Texas Air Control Board, 1965 • Texas Water Quality Act, 1967 • Texas Water Quality Board (TWQB), 1967 • Texas Solid Waste Disposal Act, 1969

Table 1. *(continued)*

Decade	Mexico	Mexican Border States	USA	Texas
1970	• Federal Law to Prevent and Control Environmental Contamination, 1971 • Ministry of Health and Welfare (Secretaría de Salubridad y Asistencia [Secretaría de Salud]–SSA) • Ministry of Agriculture and Hydraulic Resources (Secretaría de Agricultura y Recursos Hidráulicos–SARH)		• Occupational Safety and Health Act, 1970 • Environmental Protection Agency (EPA), 1970 • Clean Water Act, 1970 • Noise Control Act, 1972 • Consumer Product Safety Act, 1972 • Federal Insecticide, Fungicide, and Rodenticide Act, 1972 • Endangered Species Act, 1973 • Safe Drinking Water Act, 1974 (modified in 1986) • Hazardous Materials Transportation Act, 1975 • Solid Waste Disposal Act, 1976 • Resource Conservation and Recovery Act, 1976 (modified in 1984) • Toxic Substances Control Act, 1976	

Table 1. *(continued)*

Decade	Mexico	Mexican Border States	USA	Texas
1980	• Federal Law of Environmental Protection, 1982 • Ministry of Urban Development and Ecology (Secretaría de Desarrollo Urbano y Ecología–SEDUE), 1983 • SEDUE, 1984 • Mexican Institute of Water Technology (Instituto Mexicano de Tecnología del Agua–IMTA), 1986 • General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente– LGEEPA), 1988 (last modified: 1996) • National Water Commission (Comisión Nacional del Agua–CONAGUA), 1989	• CHIHUAHUA: State Health Law, 1987 (last edition: 2009) • COAHUILA: State Health Law, 1987 • NUEVO LEÓN: State Health Law, 1988 (last edition: 2009); Law of Ecological Equilibrium and Environmental Protection, 1989 • TAMAULIPAS: Health Law, 1985	• Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 1980 • Agency for Toxic Substances and Disease Registry (ATSDR), 1985	• Texas Low-Level Radioactive Waste Disposal Authority, 1981 • Texas Radiation Control Act, 1989

Table 1. *(continued)*

Decade	Mexico	Mexican Border States	USA	Texas
1990	• Law of Natural Waters, 1992 (last modified: 2004) • Ministry of Social Development (Secretaría de Desarrollo Social–SEDESOL), 1992 • The Attorney General of Environmental Protection (Procuraduría Federal de Protección al Ambiente–PROFEPA), 1992 • National Institute of Ecology (Instituto Nacional de Ecología–INE), 1992 • National Commission for Knowledge and Use of Biodiversity (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad–CONABIO), 1992 • Ministry of the Environment, Natural Resources, and Fisheries (Secretaría de Medio Ambiente, Recursos Naturales y Pesca–SEMARNAP), 1994	• CHIHUAHUA: Ecologic Law, 1991 • COAHUILA: Law for Ecological Conservation and Environmental Protection, 1990; Law for the Provision of Drinking Water, Drainage, and Sewerage Services, 1993; State Health Law, 1993 (last edition: 2005); Law of Ecological Equilibrium and Environmental Protection, 1998; State Law of Forest Services, 1998 • NUEVO LEÓN: Law of Drinking Water and Treatment, 1997 (last edition: 2007) • TAMAULIPAS: Law of Ecological Equilibrium and Environmental Protection, 1991; Public Service Law of Drinking Water, Sewage, Drainage, Treatment, and Disposal of Treated Water, 1992; Agriculture and Forest Law, 1994 (last edition: 2006)	• Oil Pollution Act, 1990	• Texas Natural Resource Conservation Commission (TNRCC), 1993 • HB 1920 Law regarding fiscal support incentives for the Contamination Control Equipment Program, 1993 • Initiative of law #1. Obligation of planning the conservation of water for heavy consumers, as well as contingency plans for dry spells on behalf of public water entities, 1997 • Texas Pollutant Discharge Elimination System, 1998

Table 1. *(continued)*

Decade	Mexico	Mexican Border States	USA	Texas
2000	• Ministry of the Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT), 2000 • LGEEPA guidelines regarding environmental impact, 2000 • LGEEPA guidelines regarding ecological order, 2003 • LGEEPA guidelines regarding hazardous waste, 2006	• CHIHUAHUA: Law of Promotion for Sustainable Forest Development, 2004; Law of Ecological Equilibrium and Environmental Protection, 2005 (last edition: 2010) COAHUILA: Forest Law, 2006 (last edition: 2008); Municipal Water Law, 2009; Ministry of Environmental Protection, 2009 • NUEVO LEÓN: Environmental and Natural Resources Protection Agency, 2003; Environmental and Natural Resources Protection Agency Law, 2004 (last edition: 2006): Environmental Law, 2005 (last edition: 2010); Water Institute, 2006; Law of Sustainable Rural Development, 2008; Law of Sustainable Forest Development, 2009 • TAMAULIPAS: Health Law, 2001 (last edition: 2006); Law of Environmental Protection for Sustainable Development, 2004 (last edition: 2006); Water Law, 2006; State Water Commission of Tamaulipas, 2006; Law of Sustainable Forest Development, 2007 (last edition: 2008); Environmental Agency for Sustainable Development, 2008	• Healthy Forests Restoration Act, 2003	• Texas Environmental Health Institute, 2001 • Texas Emissions Reduction Plan (TERP), 2001 • Texas Commission on Environmental Quality (TCEQ), 2002 • Environmental Monitoring and Response System (EMRS), 2004

Sources: Authors' research based on: www.tceq.state.tx.us; www.epa.gov; www.chihuahua.gob.mx; www.hcnl.gob.mx; www.congresocoahuila.gob.mx; www.congresotamaulipas.gob.mx; and Gil Corrales (2007: 161–196).

Mexico and Its Border States

Table 1 shows the development of Mexican environmental institutions. As was the case with the U.S., water resources were historically the main priority, and this paralleled development policies in Mexico.[8] Thus, in 1926 the Federal Law of Irrigation Waters established the legal basis for irrigation projects in Mexico. The law's implementing body was the National Commission on Irrigation, which was created that same year. Later on, the Water Law of 1929 and the Law of Waters of National Ownership of 1934 appeared. In 1946, a new irrigation law superseded the 1926 law, integrating new regulations on planning, construction, and operation of irrigation projects. The operational activities of this legislation and those related to potable water supply fell under the control of the Ministry of Hydraulic Resources.

As is shown in Table 1, Mexican environmental institutions evolved more slowly than their U.S. counterparts with respect to environmental principles and policies.[9] These changes began in a fragmented manner with the Federal Law to Prevent and Control Environmental Contamination of 1971,[10] which was oriented more toward public health and was implemented by the Ministry of Health and Welfare through the Undersecretariat for Environmental Improvement.

The 1980s witnessed key changes in the integration of environmental policies in Mexico. This was a result of global concerns and agreements with respect to environmental and natural resource preservation as well as the need for adaptation to new schemes of national development. The benchmark was the 1982 Federal Law of Environmental Protection that institutionalized the state's responsibility for environmental matters.[11] The LGEEPA assigned responsibility to all levels of government and established the performance of environmental impact and risk studies within the public and private sectors. The law also introduced the principles of sustainable development as the guiding framework for environmental policies (Gil Corrales 2007: 165).

The LGEEPA's broad vision of environmental problems required the development of a series of changes within government agencies. In 1992, the Ministry of Urban Development and Ecology (Secretaría de Desarrollo Urbano y Ecología–SEDUE) became the Ministry of Social

Development (Secretaría de Desarrollo Social–SEDESOL), and the National Institute of Ecology (Instituto Nacional de Ecología–INE) and the Attorney General of Environmental Protection (Procuraduría Federal de Protección al Ambiente–PROFEPA) were created to develop technical-regulatory functions and environmental protection required by law. Finally, the integrative process of environmental policies within the federal government culminated with the Secretariat of Environment, Natural Resources, and Fisheries (Secretaría de Medio Ambiente, Recursos Naturales y Pesca–SEMARNAP) in 1994. This new agency absorbed the functions of other agencies and created other decentralized bodies such as the National Water Commission (Comisión Nacional del Agua–CONAGUA), the Mexican Institute of Water Technology (Instituto Mexicano de Tecnología del Agua–IMTA), and the National Commission of Natural Protected Areas (Comisión Nacional de Áreas Naturales Protegidas–CNANP).[12]

The evolution of the Mexican federal institutions led to changes in state counterpart agencies throughout the country. In the case of the Mexican states bordering Texas, this process was also initiated in the health sector, about a decade after the federal government began changes in this area (Table 1). The creation of the federal LGEEPA was accompanied shortly thereafter by the appearance of its state equivalents. From this point forward, the states followed a more dynamic process with reforms to their respective environmental legislation[13] and the creation of specific agencies and offices to govern them.

The previous analysis leads to the conclusion that the environmental institutions that converge at the subnational level along the Mexico-Texas border have a comparable update status with respect to the current principles of the concept of environmental sustainability, although this has been the result of different processes within the political-administrative context of each country. In the case of Texas, the evolution of its state institutions has been accompanied by autonomous agencies and entities for implementation.[14] Texas' four counterpart states in Mexico have to a large extent centralized the implementation of the environmental legislation within their statewide agencies in coordination with federal counterparts.[15]

The Practice of Sustainability along the Mexico-Texas Border

The group of institutions reviewed previously established the guidelines for regional planning on both sides of the border and the specific agencies in charge of implementation. These frameworks have adopted sustainability principles and have integrated them into their specific policies. This section will examine the degree of integration within the specific planning instruments applied at the subnational level.

To understand regional planning in the Mexican border states, we must recognize that regional planning comes from a tradition whose basic element is the centralized political system that characterizes Mexico's political-administrative structures. By law, each federal administration unit must produce a National Development Plan that outlines specific objectives and guidelines in various areas for the next six years.[16] This plan is the basis for different sectoral programs and plans developed by the federal government through its various agencies and offices in coordination with state and municipal governments.

The states also have contemplated a similar type of six-year development plan that integrates the political objectives of the current state governments with the current National Development Plan. These plans' implementation is the responsibility of the relevant state agencies in coordination with municipal governments.

As opposed to the centralized development plans in Mexico, regional planning in the United States involves a considerable larger number of agencies at the different levels of government depending on the specific objectives and the geographical or political coverage in question. The autonomy within the U.S. political-administrative system for non-federal agencies permits the existence of decentralized agencies and entities that are able to focus more specifically on regional environmental issues. The corresponding plans and programs integrate the interests of local governments and counties and establish specific criteria with respect to communication, planning, public policy, financing, and technical assistance in order to focus effectively on the problems and needs of the communities served.

For the purposes of this section, we compared Mexican border states' development plans for the last decade and specific environmental plans for the state of Texas. The corresponding criteria of analysis are shown in Table 2. Key to this analysis was the evolution of the concept of a sustainable environment within the instruments reviewed at both general and specific levels, including the strategies or guidelines outlined within the plan. The more relevant points of this analysis are shown in Table 2.

Mexican Border States

The planning mechanisms within the Mexican states that border Texas generally have similar characteristics, with some differences. First of all, it is important to point out that, in general terms, such instruments have evolved over the last decade in terms of their specificity. The environment and natural resources, for example, have gained more importance within the most recent plans and are seen as topics and problems that require special analyses and approaches. Environmental sustainability principles and the discussion on preserving the environment have also been slowly finding a place within the states' overall visions as well as with state plans.[17]

This appears to coincide with an accumulative and ongoing process of more available information and therefore a greater understanding of environmental issues outside of the traditional subject of water.[18] Although it is possible to still have environmental topics included outside of environmental policy, in general it is understood that these topics are part of an increasingly important focus on the environment in the states.

Water and its availability are environmental sustainability topics that have always occupied a particular place within the priorities of regional planning in Mexico. This is due to its importance in terms of support for the economic and social policies of current governments. Throughout the different state governments, this topic has evolved from a focus on traditional objectives—such as increasing the available water supply and the coverage of drinking water and sewage systems—toward addressing more complex problems such as the contamination of water sources in urban and rural areas; increasing management efficiency; and looking for formulas that impact the demand for water, such as water recycling or awareness campaigns

Table 2. Subnational Instruments: Analysis Criteria

General Area	General Criteria
Regional vision and identification of problems	• Vision proposed by the region and its articulation with the concept of sustainability • Incorporation of interactions and processes on both sides of the border within the vision • Problems relevant to environmental sustainability perceived within the proposed vision
Empirical basis	• Diagnosis regarding the current situation of the environment and natural resources as well as the limitations imposed by future development of the region
Action guidelines	• Relevant goals and objectives of environmental sustainability • Principles and guidelines for implementing the plan • Identification of strategies and concrete actions
Implementation	• Specific programs to implement strategies and actions • Temporary horizons of strategies and actions • Responsible organizations/entities • Identified finance resources
Follow-up and evaluation	• Formulation of goals in terms of measurable results • Indicators for the evaluation of advancements (e.g., number of residents with health services) • Responsible entities
Internal consistence	• Correspondence between proposed goals and the vision • Linking action guidelines with objectives and programs • Relevance of proposed indicators in order to measure achievement of objectives
Interinstitutional coordination	• Mechanisms of vertical and horizontal coordination with other plans or policies from federal, state, and municipal governments • Importance given to collaboration and coordination on both sides of the border

Source: Authors, based on Castro and González 2009.

directed to the different users. But without a doubt, an important pending issue is the right and need that ecosystems and species have for water (along with human beings) in the border region.

Additional topics that have gained importance within state policies over the last decade include the handling of solid waste, urban atmospheric contamination, and environmental education. The informational base for these subjects has gradually increased through the characterization and establishment of general policy guidelines as well as the statement in some cases of more specific measures. These proposals show changes between administrations, suggesting the need to develop and undertake actions that complement the actions already implemented. Coahuila and Nuevo León have recently developed plans that contain the most number of specific proposed actions on these subjects.

International planning is a key aspect of border states' regional planning. Among the Mexican border states, there are a variety of approaches taken with the state of Texas in terms of policies ranging from infrastructure improvement for ports of entry to industrial infrastructure development to regional economic development. Sustainable development appears as a general idea within these policy areas but is not yet present in concrete actions.[19]

The state development plans in Mexico embrace a broad spectrum of problems and needs that the current state government considers as priorities to be addressed during the corresponding administrative period. This implies, on the one hand, that the priority areas will not necessarily be the same from one administration to another and, on the other hand, that not all strategies or established actions in a plan will be addressed (primarily for budgetary reasons) given the dependence that these instruments have on federal resources for their implementation.

In this context, and despite the aforementioned advances, the integration of environmental topics to more operative levels still appears to be secondary to the principal priorities of current state governments such as economic and social development and related issues.

Environmental Planning in Texas

The Texas mechanisms are representative of regional planning processes that are developed within the U.S. federal system. State plans are the responsibility of the agencies created by the state legislation. In regard to the environment and natural resources, the agencies that develop and implement two of the most important plans at the state level are the TCEQ[20] and the Texas Water Development Board (TWDB).[21] The vision and mission of these agencies are usually reflected in their respective mechanisms and are a product not only of an operational evolution of the initial agencies, but also of a constant conceptualization of the environmental problems that are addressed. Currently, environmental sustainability is a part of these scenarios and goals.[22]

The regionalization that Texan agencies present in their administrative and planning functions serves to decentralize and facilitate the different stages of a state plan. The required diagnosis of the conditions or problems to be addressed, as well as the proposal of more specific strategies or actions or programs, have this regional structure as their basis.[23] The state water plan, for example, represents the integration of the plans issued by the 16 Regional Water Planning Groups (RWPGs) that make up the TWDB. This planning scheme from bottom to top ensures also the plan's internal consistency and verification of progress, as well as the management of financial resources for its implementation.[24]

An important aspect of environmental planning in Texas is the geographical coverage of the border region with Mexico within this overall scheme of administrative decentralization. The regional offices can establish their own relationships and set their own planning guidelines within their own jurisdictions. This allows them to establish links with their Mexican counterparts at different government levels.[25]

In summary, environmental agencies in Texas are independent in terms of their functions, tasks, and goals, including their financial capacity. In addition to the advantages that the specialization of these agencies offers in different areas, it also allows continuity in addressing goals and challenges regardless of changing administrations in state government. Because of this, the objectives, goals, and regional programs are not exposed to problems or changes as a result of centrally made decisions. The plans of these agencies present structural clarity compared to the plans of their Mexican counterparts in the sense that they incorporate established mechanisms and are regulated by law to ensure the attainment of goals and objectives. By doing this, they ensure the successful implementation of conceptual principles of the mission and vision in actions and programs that impact environmental conditions and quality of life for the public.

Conclusions: Future Scenarios

In this paper, we have presented a comparative analysis of the concept of environmental sustainability and how it is incorporated into institutional and regional planning frameworks at the subnational level at the Mexico-Texas border. Although not exhaustive, this first analysis allows us to reach some conclusions in terms of trends in the evolution of environmental issues and the concept of environmental sustainability in subnational planning at the U.S.-Mexican border.

First of all, at least at the institutional level, there is a comparable advancement on both sides of the border in regard to the terms of incorporation and recognition of the principles of sustainability. In general, Mexican environmental legislation saw important changes during the last decade as states adapted to new needs imposed by environmental problems in the border states.[26] With respect to the region's legal mechanisms, and recognizing the deep political-administrative differences on either side of the border, sustainability and environmental topics in the U.S.-Mexican border region have moved beyond theory toward the generation of better information and understanding.

The current positive changes in environmental sustainability in Mexico's northern border region will continue to be subject to the region's social and economic dynamism in the future. This calls for new public policies that are focused on providing strategies, actions, and solutions that survive successive administrations and provide for the sustainability of natural resources.

There is already a good starting point for the border region's binational institutions. These include the institutions created by the North American Free Trade Agreement (NAFTA), the current Border

2012 Program and its workgroups, and additional work carried out by civil society groups (Spalding 2000). There are also advances at the subnational level as well as a number of pending items in the Mexican border states. It is thus important to consider a binational plan or scheme of environmental administration that acts with a certain degree of autonomy and promotes true sustainable development of the border region in the long term.[27] This plan could incorporate the necessary mechanisms for ensuring continuity of strategies and programs in terms of policies and financial resources. The basis for this, although incipient in the Mexican border states, already exists in the binational initiatives undertaken by state governments.

Thus, we can say that environmental topics will continue to gain presence at the conceptual level within border planning. These advances will occur mainly on the Mexican side and will reference the operational advancements that already exist in the United States. As more information becomes available, the plans will tend to consolidate environmental topics within the policy areas including development, environment, and natural resources preservation (within the overall concept of sustainability). Mexican state operational plans will not advance without mechanisms that allow for policy continuity over the medium and long term. The principal limiting factors are the traditional priorities articulated by the state plans and the traditional public administrative calendar of Mexico.

Endnotes

[1] Sustainability can be understood as the efforts that are being developed by humanity in regard to covering its present needs without compromising the needs of future generations.

[2] Under its current concept, sustainability covers an ample array of topics that involves the economic, social, and environmental dimensions that makes its operation and measurement difficult within the practical field. In line with the objectives of this project, the only perspective considered here is the environmental one. An operational definition in this sense will be: the maintenance of those factors and practices that contribute to the quality of the environment in the long term.

[3] The agencies and entities created specifically for the implementation of this legislation, by law, must coordinate with their federal counterparts on the development of specific projects and actions.

[4] A number of major events helped trigger the environmental movement in the United States beginning in the 1950s, including marine contamination by oil spills and the presence of heavy metals. Also important were a number of key books, including *Silent Spring* by Rachel Carson, which appeared in 1962.

[5] NEPA was an important starting point in the sense that it outlined principles within the overall concept of sustainability, including the creation and conditions under which humans and nature "can coexist in productive harmony and satisfy the social, economic and any other type of need of present and future Americans" (epa.gov). The new legislation established three main pathways to accomplish this: the establishment of goals and environmental policies at the national level; action guidelines for these policies via different agencies; and the creation of the President's Council on Environmental Quality (CEQ).

[6] The 1960s were particularly important for this trend and witnessed several of the more relevant legislative initiatives and agencies that followed federal guidelines. The TBWE became the Texas Water Commission and assumed additional responsibilities with respect to water conservation and pollution control. In addition, the water and air control boards had their beginnings at this time (www.tceq.state.tx.us).

[7] Within its current organization, the TCEQ's central mission is to protect the state's natural and human resources within a framework of sustainable development. The Commission's specific objectives focus on clean water and air resources and safe waste management (www.tceq.state.tx.us).

[8] The 1917 Constitution, and particularly Article 27, represents the point of departure for the different legislation that have governed the use and ownership of national resources up until now. The article established that water is the property of the nation and that the state has the exclusive authority to regulate its use, exploitation, and distribution. This concept was maintained in the legal structures regarding national waters that were developed afterward (Castro and Sánchez 2001).

[9] It is important to note that before the 1970s—and similarly with the case of water resources—at the federal level a vision that prevailed was more of a production type with respect to the management of other natural resources such as forests or wildlife.
[10] There is an isolated precedent for this legislation: the Law of Land and Water Conservation of 1945 sought to promote, protect, and regulate the conservation of land and basic water resources for national agriculture (www.ine.gob.mx).
[11] The entity in charge of implementing this law was the SEDUE, which had four basic functions: ecological regulation, pollution control and prevention, conservation of natural resources, and environmental outreach. In 1984, the structure of the SEDUE was added; this was a decentralized body whose objectives were technological and scientific research, development, promotion, and coordination within the area of urban development, housing, and ecology (Gil Corrales 2007: 161–163).
[12] In November of 2000, SEMARNAP was modified into its current structure and functions, removing the fishing sector and shifting its activities to be more in line with the objectives of environmental policies. A fundamental change in this process was the integration of the sustainable development paradigm within the National Development Plan of 2001–2006 as the governing axis of environmental policies within the country (Gil Corrales 2007: 175).
[13] The state-level legislative instruments that had the LGEEPA as their basis did not necessarily ratify the principal theories of sustainable development but rather defined how to address this challenge in an operational fashion. As these laws evolved (basically during this decade), the principles of sustainable development have evolved into being an integral part of these laws.
[14] The culminating point of this change is the evolution of the TCEQ, which currently takes on multiple functions as does its federal counterpart, the EPA.
[15] Currently, decentralized agencies have emerged with the purpose of confronting environmental problems within these states, but there continues to be close dependence of these with statewide agencies. Examples include the Environmental and Natural Resource

Protection Agency of Nuevo León; the Environmental Agency for Sustainable Development of Tamaulipas; and recently, the Ministry of Environmental Protection of Coahuila.

[16] Mexico's Federal Law of Planning of 2003 articulates the elaboration, implementation, and follow up of the National Development Plan as part of the responsibilities of the federal executive branch. It also establishes guidelines for the coordination of regional planning along with the participation of the state and municipal governments through corresponding provisions of the National System of Democratic Planning.

[17] With the exception of Nuevo León, the state plans generally consist of a vision that is supported by various points that address principal policy commitments of a government in power.

[18] This presence of the concept is possibly a result of the influences of international tendencies in the matter, as well as the consequent changes that have been generated within the instruments of development and legislative frameworks at the national level. Another condition that can play a role here—although the instruments analyzed do not clearly contemplate it—is the evolution of the binational institutional framework built by both countries in order to confront environmental problems and the activities that have derived from this framework such as the projects undertaken by BECC and NADB or the activities of the binational workgroups established by the Border 21 program (Castro and González 2009).

[19] Nuevo León has progressed the most with regard to the development and integration of its border area with Texas. In 2005, it created the Texas-Nuevo León Strategic Environmental Plan with the purpose of establishing a framework of cooperation between its two primary environmental agencies—the TCEQ and the Environmental and Natural Resource Protection Agency of Nuevo León—and to draft an action plan to address common environmental issues (Governments of Texas and Nuevo León 2005).

[20] The most immediate predecessor of TCEQ is the TNRCC, an agency created in 1993 with the goal of integrating for the first time state regulatory programs for water, air, and waste. The TCEQ groups environmental problems that merit attention in four large categories of air, water, waste, and others. With regard to the air group, the agency's functions focus on air pollution control in accordance with

the requirements of the Federal Clean Air Act (FCAA). With regard to water, coverage includes water quality in rivers, lakes, bays, and other surface waters starting from nonpoint pollution from all source types except agriculture and forestry (forest management). The waste area includes low-level radioactive waste, by-product materials, uranium, and electronics industry waste.

[21] TWDB was created in 1957 to develop water supply projections for the state and to finance water supply and conservation projects. Its current mission incorporates other functions such as planning, financial support, information, and education for the conservation and responsible water development in Texas.

[22] There are other types of plans that are implemented at the state level, whose purpose is the application of federal legislation (e.g., the Federal Clean Air Act), within which there is no specific vision established since they are an operational effort of different agencies at the three levels of government. In such cases, the vision and the mission of each participating agency are according to the law.

[23] In the case of delegations or regional groups, the strategies and guidelines may vary, as well as the particular programs to carry them out.

[24] The legal framework of the responsible agencies foresees in each case the financing of state plans in a decentralized manner. Another important source of financing corresponds to application funds of state or federal programs, as is the case with the current Texas Emissions Reduction Plan.

[25] Since 2008, the TCEQ has an action plan in place to specifically address environmental problems along the border with Mexico that includes air pollution issues, water pollution, and solid waste as well as emergency response (www.tceq.texas.gov).

[26] Evidence of this evolution is seen in the rise of specific agencies in some states such as the Agency for Environmental Protection and Natural Resources of Nuevo León and the Environmental Office of Coahuila.

[27] One idea for a new binational institution that has been advanced is a binational watershed council that would convene key governmental and civil society organizations (Brown and Mumme 2000).

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V

A Critical Review of Public Participation in Environmental Decision Making along the U.S.-Mexican Border: Lessons from Border 2012 and Suggestions for Future Programs

Allyson Siwik, Elaine Hebard, and Celso Jáquez

Abstract

As a direct result of economic development agreements such as the North American Free Trade Agreement (NAFTA), the U.S.-Mexican border region has been, is, and will continue to be confronted by a long list of critical environmental problems to resolve. The U.S.-Mexican border environmental programs—Integrated Border Environmental Plan (IBEP), Border XXI, and Border 2012—in conjunction with the NAFTA institutions of the Border Environment Cooperation Commission (BECC) and North American Development Bank (NADB)—have made significant progress in addressing the region's infrastructure needs for water and wastewater and management of binational air quality, as well as of hazardous and solid wastes. This progression of border programs resulted in a shift from a top-down management approach to a more locally directed one. This paper discusses the evolution of public participation since Border Institute I in 1998. Drawing on years of direct involvement and upon

specific case studies, the authors describe the current status of public participation to summarize what is effective and what is not working. Future climate change impacts, border security, and economic development pressures will impose continued and increasing challenges to the region's environmental sustainability and to its citizenry. It will be critical that binational public participation in decision making related to these problems is ensured and enhanced. The authors recommend specific institutional changes and binational policies to address existing programmatic weaknesses and emerging demands related to public participation.

The Case for Public Participation

Public participation is important to our democracy and to our ability as a society to make sound decisions related to the pressing challenges of our time. Participatory democracy creates opportunities to involve stakeholders potentially affected by a decision.[1] Public participation is important for all sectors of society interested in creating accountability and transparency in the decision-making process in order to develop more effective public service programs and successful solutions to tough societal problems.[2] Table 1 details a spectrum of public participation[3] while Table 2 summarizes core values for public participation.[4]

In the context of environmental decision making, a recent seminal study by the National Academy of Sciences concludes that public participation processes, when done correctly, improve the quality and legitimacy of a decision and build the capacity of all involved to engage in the policy process. Public participation can lead to better results in terms of environmental quality and other social objectives; in addition, public participation can enhance trust and understanding among parties.[5]

Table 1. A Spectrum of Public Participation

Increasing Level of Public Impact					
	Inform	Consult	Involve	Collaborate	Empower
Public participation goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities, and/or solutions.	To obtain public feedback on analysis, alternatives, and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
Promise to the public	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Table 1. *(continued)*

	Increasing Level of Public Impact				
	Inform	Consult	Involve	Collaborate	Empower
Example techniques	• Fact sheets • Web sites • Open houses	• Public comment • Focus groups • Surveys • Public meetings	• Workshops • Deliberative polling	• Citizen advisory committees • Consensus-building • Participatory decision making	• Citizen juries • Ballots • Delegated decision

Source: International Association for Public Participation 2007.

Table 2. Core Values for Public Participation

The purpose of these core values is to help make better decisions which reflect the interests and concerns of potentially affected people and entities.

1. Public participation is based on the belief that those who are affected by a decision have a right to be involved in the decision-making process.
2. Public participation includes the promise that the public's contribution will influence the decision.
3. Public participation promotes sustainable decisions by recognizing and communicating the needs and interests of all participants, including decision makers.
4. Public participation seeks out and facilitates the involvement of those potentially affected by or interested in a decision.
5. Public participation seeks input from participants in designing how they participate.
6. Public participation provides participants with the information they need to participate in a meaningful way.
7. Public participation communicates to participants how their input affected the decision.

Source: International Association for Public Participation 2007.

The Rio Declaration on Environment and Development of 1992 included public participation in its 27 principles. Principle 10 states that "environmental issues are best handled with participation of all concerned citizens, at the relevant level." The Rio Declaration continues, drawing a close link between access to information and public participation:

> At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.[6]

The United Nations Economic Commission for Europe Aarhus Convention on Access to Information, Public Participation in Decision-making, and Access to Justice in Environmental Matters became effective in 2001.[7] This convention provides for detailed provisions to ensure the public participation rights of individuals and organizations according to three distinct "pillars": access to environmental information; public participation in decisions on specific activities, particularly plans, programs, and policies relating to the environment; and access to justice.[8]

Assuming that public participation is linked to good governance and successful environmental quality outcomes, how can it be evaluated to show improvements? As stated in the National Academies report, "Processes can be seen as more or less participatory along several dimensions, notably breadth (who is involved), timing (how early and at how many points in the overall decision-making process they are involved), intensity (e.g., the amount of time and effort participants spend and the degree of effort made by conveners to keep them involved), and influence."[9] These key measurement areas can help define public participation indicators and evaluate whether or not public participation strategies are working effectively.

Public Participation concerning U.S.-Mexican Border Environmental Issues

With respect to U.S.-Mexican border environmental issues, public participation has been recognized as a necessary ingredient to develop effective binational solutions to transboundary environmental problems. Providing the framework for U.S.-Mexican cooperation on border environmental issues, the La Paz Agreement of 1983 and its associated implementation programs—IBEP, Border XXI, and Border 2012—"deserve to be seen as the first and most important in a series of binational agreements institutionalizing and broadening the opportunities for public participation in transboundary and border area environmental management."[10]

In the early 1990s, the NAFTA institutions—the Border Environment Cooperation Commission (BECC), the North American Development Bank (NADB), and the Commission for Environmental Cooperation (CEC)—were created with significant input from national nongovernmental organizations (NGOs). The implementation of these programs explicitly requires public participation. For example, local stakeholders, including community groups, citizens, the business sector, universities, and local governments, participate through BECC's public participation procedures for project certification. As Stephen Mumme writes, "Viewed from a historical perspective this enhanced political opportunity for citizen influence in government decisions affecting the border environment is certainly one of the defining achievements in recent times in U.S.-Mexican relations and one that is qualitatively vital for the region's democracy as well as its environment."[11]

In general, public participation in border environmental decision making has been strengthened since the signing of the La Paz Agreement in 1983. A brief summary of the genesis of border environmental cooperation is provided to clarify the evolution of public participation in the U.S.-Mexican border region.

The 1983 La Paz Agreement provided a framework for "developing cooperative environmental efforts to reduce, eliminate or prevent sources of air, water and land pollution."[12] In the early stages of binational cooperation under this agreement, most activities largely occurred between the two federal governments, through agencies responsible for specific environmental issues, such as the U.S. Environmental Protection Agency, Mexico's Secretariat of Urban Development and Ecology (Secretaría de Desarrollo Urbano y Ecología–SEDUE), and the International Boundary and Water Commission (IBWC)/Comisión Internacional de Límites y Aguas (CILA). Established under annexes to the La Paz Agreement, binational workgroups for water, air, hazardous waste, emergency response, enforcement, and pollution prevention were authorized to identify problems and develop joint solutions.[13] Federal agencies were encouraged to work with state and local governments and NGOs, although there was no requirement to do so.[14]

The Integrated Border Environmental Plan (IBEP) for the Mexican-U.S. Border Area was released in early 1992 and was the first "implementation plan" of the La Paz Agreement that laid out how the two governments would cooperate on resolving border environmental issues. Covering a two-year period, the plan was "created under the assumption that increased liberalization of trade would place additional stress on the environment and human health along the border."[15] It outlined a list of border environmental problems, but left the detailed activities to later programs. The IBEP was developed by a Boston consulting firm[16] and received strong criticism at public meetings by border stakeholders,[17] such as lack of sufficient funding and specificity, avoidance of crucial environmental issues, and incorporation of policies dictated by Washington, D.C., and Mexico City, rather than by the border region.[18] In the words of the U.S. Environmental Protection Agency (EPA), "the lack of formal public input detracted from its public support."[19] The IBEP emphasized capacity-building activities such as information sharing and training assistance, as opposed to enforcement of environmental regulations and joint planning. During this time, the U.S. provided technical assistance and training to Mexico in areas such as the development of environmental regulations, air pollutant emissions inventories, and hazardous waste tracking systems.

As the second iteration of implementation of the La Paz Agreement covering the period 1996–2000, the Border XXI Program's principal goal was to promote sustainable development "by seeking a balance among social and economic factors and the protection of the environment in border communities and natural areas."[20] The strategies used to accomplish that goal were threefold: (1) ensure public involvement; (2) build capacity and decentralize environmental management; and (3) ensure interagency cooperation.[21] There was recognition that Border XXI was "initiated to build on the experiences of and improve the specific efforts undertaken under the IBEP and earlier environmental agreements."[22] Nine borderwide workgroups were established to address media-specific problems: air quality; contingency planning and emergency response; cooperative enforcement and compliance; environmental health; environmental information resources; hazardous and solid waste; natural resources; pollution prevention; and water. Most of these were a continuation of the La Paz and IBEP workgroups, but Border XXI created three new workgroups based on public input, recognizing the need for binational cooperation on environmental health, environmental information, and natural resources. Geo-specific sub-workgroups were also created at the regional and local levels to address concrete issues.

The comments from border stakeholders on the weaknesses of IBEP helped the U.S. and Mexican governments to recognize the importance of public involvement in the planning and implementation of border environmental initiatives. Therefore, public involvement was identified as one of three strategies to achieve sustainable development in the border region under the Border XXI Program. According to EPA, in 1995–1996, more than 20 public meetings were held in U.S. border cities, regional and state-level meetings were held in Mexico, and three binational public meetings were organized to solicit public input on the Border XXI Program before and after the Framework Document was developed.[23] The addition of three new workgroups was identified by EPA as a structural change to the border program as a result of public comment.[24]

Border XXI also outlined seven public involvement objectives and activities mostly focused on providing information, improving access to environmental information and the border program, public engagement in Border XXI workgroups, and development of additional channels for public input to the border program. Border XXI implementation plans and accomplishments were produced and made available via the internet. Regional and local sub-workgroups were created to engage stakeholders in planning. The Good Neighbor Environmental Board (GNEB) and Mexico's Advisory Councils for Sustainable Development (Consejos Consultivos para el Desarrollo Sustentable–CCDS) provided input on Border XXI implementation. EPA provided financial resources to the Southwest Consortium for Environmental Research and Policy (SCERP), a consortium of 10 U.S. and Mexican universities, to conduct applied research in the border region. EPA also established the San Diego and El Paso Border Liaison Offices to provide information on border environmental issues and to obtain feedback on those issues from the public.[25]

The binational Joint Advisory Committee (JAC) for the Improvement of Air Quality in El Paso, Texas, and Ciudad Juárez, Chihuahua, has been held up as a successful model of public engagement in the Border XXI Program. According to Mumme, "The Committee, which is not only binational, but truly melds federal, state, local, and citizen participation, has indeed contributed to local capacity for environmental protection and serves as a useful model for developing cooperative, locally supported procedures for environmental protection in sister-city communities along the border."[26]

In addition to the Border XXI Program, public participation is an essential ingredient of the BECC/COCEF program:

> In contrast to IBEP, which built on the ongoing La Paz process, the BECC/NADB initiative created a new and substantial institutional arena for public participation, centered in the BECC. By design, the BECC directly responded to community demand for greater voice in border environmental affairs. Its binational advisory board made of 10 members was composed of federal, state, and local government representatives from each side of the border, as well as one nongovernmental advocacy group representative from Mexico and one from the United States. BECC's procedural rules stressed administrative transparency and access to nonproprietary information. Board meetings were open and available for public comment, and its certification procedures required the formation and input of local public advisory groups for project development and approval. Projects exceeding basic sustainability criteria that included public participation requisites were fast-tracked for Board approval. By incorporating public participation directly in the development and approval of its projects, the BECC substantially broadened the arena and the opportunities for citizen engagement in border area environmental policy, including some of the most substantial projects that could and would be undertaken in the name of public health and environmental improvement.[27]

Border Institute I: Evaluation of Public Participation in Border XXI

Despite the significant gains made in strengthening public participation in the border program, Border Institute I researchers cited a variety of problems and barriers to public participation. Convened in 1998, Border Institute I took place during the Border XXI Program. The Border Institute I survey of binational efforts to address border environmental problems[28] critiqued the Border XXI Program in general:

- Border XXI was not sufficiently transparent, participatory, multimedia, or interdisciplinary in focus.
- City and state governments on both sides of the border often lack the basic resources and information needed to address environmental issues.
- The program is not designed to be proactive and prevent environmental degradation from unsustainable development. Unless radically redesigned or supplemented with a much broader planning and regulatory enforcement structure, it will never do more than treat the symptoms of the disease.
- Border XXI lacks long-range planning and ecosystem planning, and has very little watershed analysis and management.
- The program needs increased participation by the private sector.
- Border XXI should provide a long-term vision for the border in order to incorporate sustainable development policies in planning and implementing border region projects.

During that same time period, some of Border XXI's shortcomings were raised to the U.S. Trade Deficit Reduction Commission: [29]

- The Border XXI process remains a process dominated by federal agencies on both sides of the border whose programs are deployed in an ad-hoc, poorly prioritized fashion.
- Border XXI has, to date, downplayed—some would say neglected—several of its cardinal strategies for promoting sustainable development on the border: fostering public participation in environmental protection and building capacity and decentralizing environmental management on the border. While genuine efforts have been made to disseminate information, improve public access to government officials, and build in greater responsiveness to border constituencies, the decision-making process is still fragmented and indirect. It is instructive that when EPA touts its efforts in public participation, it points to its annual meetings under the La Paz Agreement, new border environment information centers, a few joint advisory boards, the GNEB, the BECC, and to Mexico's efforts to create public forum committees at state and local levels to advise on hydraulic infrastructure development. With the possible exception of the

BECC, these institutions tend to be rather formal, government-dominated arenas whose agendas are difficult to access and, hence, are shaped without much grassroots influence.

- Border XXI's emphasis on environmental policy decentralization and state-local capacity building is tacit acknowledgement of the need to move beyond federal tutelage in building up local participation and administrative capacity for environmental protection in the border area.
- Border XXI can point to few concrete accomplishments by way of enabling local governments and communities to assume greater responsibility in delivering environmental values to their citizens. While a number of Border XXI projects claim to indirectly contribute to local capacity accrual and decentralization, very few aim explicitly at this goal. One remarkable exception to this pattern may very well be the binational Joint Advisory Committee for the Improvement of Air Quality in El Paso, Texas, and Ciudad Juárez, Chihuahua.

The Good Neighbor Environmental Board also provided its assessment of the Border XXI Program.[30] The Border XXI Program "is still heavily focused on federal interaction and has not fully succeeded in building local capacity or in thoroughly fostering public support. It has, however, made the work of the La Paz workgroups more accountable to the public through their individual transparency or failure to work transparently. ...The workgroups should also do more to emphasize environmental education efforts throughout the border region. Investing in future generations and promoting environmental education at all levels will help border communities develop the long-term technical skills, interest and knowledge necessary to address local problems. ...The GNEB hopes to see more rapid decentralization and greater local empowerment as the Border XXI Program continues to mature. This delegation of authority and the need for more local implementation should be accompanied by a commensurate distribution of funding to support the tribal, state and local involvement which is vital to the success of the Program."

Border 2012—Recommendations regarding Public Participation

> **Border 2012: U.S.-Mexico Environmental Program Mission Statement**
>
> As a result of the partnership among federal, state and local governments in the United States and Mexico, and with U.S. border tribes, the mission of the Border 2012 program is:
>
> To protect the environment and public health in the U.S.-Mexico border region, consistent with the principles of sustainable development.[1]
>
> [1] In this program, sustainable development is defined as "conservation-oriented social and economic development that emphasizes the protection and sustainable use of resources, while addressing both current and future needs and present and future impacts of human actions."
>
> Source: EPA-160-R-03-001, May 2003, http://www.epa.gov/usmexicoborder/docs/FrameworkDocument2012-eng.pdf.

The latest La Paz implementation program, Border 2012, was signed in April 2003 and covers a 10-year period to 2012. Addressing some of the issues and concerns raised under Border XXI, this program emphasizes binational partnerships and collaboration as a means to achieving environmental results. The 10 border states and U.S. tribes joined EPA and Mexico's Secretariat of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT) as full partners in the development and implementation of the program. Leveraging of knowledge, resources, and expertise among partners is a cornerstone of the program's strategy to meeting Border 2012's goals and objectives. Based on border communities' input, the program also reaffirms a commitment to fostering transparency and public participation and improving stakeholder participation.[31]

Some key programmatic changes incorporated in Border 2012 are aimed at improving stakeholder involvement in the program. The program adopts a bottom-up approach for setting priorities and in decision making, such that local stakeholders are included in identifying priorities and developing and implementing solutions. This represents a major departure from previous implementation programs that were directed from the two federal capitals.

Structurally, the borderwide workgroups and sub-workgroups of Border XXI were reorganized into four regional workgroups covering the entire border, with multiple media-specific and geo-specific task forces within each regional workgroup. Rural areas and tribal communities that were previously ignored were incorporated into the Border 2012 Program. For example, southwestern New Mexico-northwestern Chihuahua and the greater Presidio-Ojinaga area were included as multimedia "rural task forces" within the New Mexico-Texas-Chihuahua Regional Workgroup.

Borderwide workgroups in environmental health, emergency preparedness and response, and cooperative enforcement and compliance, as well as policy forums on air, water, and waste are led by the two federal governments to cover borderwide issues that can only be resolved at the federal government level. Task forces are led by a combination of state and local agencies, community members, and university researchers, depending upon the region.

In order to obtain and maintain stakeholder participation in the program, Border 2012 provides travel reimbursement to task force co-leaders to attend regional workgroup and national coordinators meetings. Financial support from Border 2012 for task force coordination and project implementation varies along the border.

In the words of a San Diego-Tijuana border stakeholder speaking at the 2009 Border 2012 National Coordinators Meeting in Valley Center, California, "The Border 2012 Program has been really useful and productive as a convener, bringing together representatives of two governments and two communities, furthering cross-border collaboration and solidarity. The experience of working together strengthens our confidence in each other, helps transcend differences, builds understanding, and helps ensure transparency." In their experience, she added, "The Program has functioned as a very inclusive structure; local community organizations have been able to participate and benefit, and that aspect should be maintained in the Program. It has also served as a neutral, democratic authority that built consensus."[32]

A university researcher from San Diego expressed that one of the great achievements of Border 2012 has been its capacity for bringing together the main stakeholders on both sides of the border, which has filled a real gap in addressing border environmental issues. For example, when there is a change in administration on either side of the border, Border 2012 remains to remind the incoming administration that it has an obligation to address border environmental issues.[33]

Taken together, these measures have served to strengthen binational relationships at the local level where weak or nonexistent relationships to discuss and deal with environmental issues may have existed before. Have they been sufficient to address the shortcomings noted?

Border 2012 Public Participation

Rural Task Force Example

The authors of this report have been involved with the New Mexico-Chihuahua Rural Task Force since its inception so they have first-hand knowledge of how Border 2012 is being implemented within this rural area of the border. Established in 2005, the Rural Task Force was modeled after the Joint Advisory Committee. The vision was to provide a forum for public engagement in environmental decision making in this region of the border. The first meeting was held in the small town of Janos, Chihuahua. Much to the co-leaders' surprise, approximately 100 people from both sides of the border attended the meeting, representing farmers; local, state, and federal government agencies; universities; local primary and secondary schools; citizens; and NGOs. The meeting featured presentations by local citizens, agencies, and organizations on a range of environmental issues in the Rural Task Force region. Meeting participants created a comprehensive list of environmental issues and then through multivoting (i.e., each participant placed colored dots on his/her top three environmental issues), environmental problems were rank ordered. The top three issues identified through this process were air quality, water quality/quantity, and conservation of the Chihuahua Desert ecosystems.

The Task Force conducted its work over the next 12 months through subcommittees that addressed each of the three priority areas. Working through consensus, a strategic plan was developed that outlined the goals and objectives for each of the priorities along with specific activities or projects to meet each of those objectives by 2012. This strategic plan has continued to guide the work of the Rural Task Force since its completion in 2006. Subgroup meetings continue to be convened to obtain additional input and participation in carrying out various projects. At the Task Force's annual meetings, participants report out on projects and provide an update on progress achieved. Midcourse corrections are made through consensus and the strategic plan is updated annually to reflect completed tasks and new tasks as appropriate.

Activities of the New Mexico-Chihuahua Rural Task Force to date include: performing an inventory of scrap tire piles and cleaning up 6,000 scrap tires from the region; inventorying paved/unpaved roads and disturbed land that cause particulate matter air quality problems in Columbus-Palomas and developing recommendations for dust control; providing workshops on alternatives for dust control and scrap tire management and disposal; establishing a binational water dialogue on Mimbres Basin groundwater issues; holding a binational water tour to identify and discuss shared water problems in the region; supporting environmental fairs; developing an online interactive map as well as a website highlighting activities, hosted by New Mexico State University; developing a Rural Task Force webpage and e-mail distribution system; and developing environmental education (EE) trunks for each of the three priority environmental problems in the region and training teachers to deliver the EE curricula in primary and secondary schools throughout the Task Force region.

Roadmap - A Draft Model for Collaborative Operation of Transboundary Watersheds

The lack of consistent information about the Mimbres transboundary aquifer—shared by Columbus, New Mexico, and Palomas, Chihuahua, as their sole source of water—makes it difficult for residents to make rational choices among proposed uses of water and for government agencies to administer water resources. Many other transboundary basins face similar issues and there are several endeavors under way to address noted deficiencies. The Roadmap was developed by the Rural Task Force's Mimbres Basin Dialogue in an attempt to incorporate ideas on institutions, tools, treaties, agreements, protocols, and coordination into a workable framework to care for a binational basin. To create and sustain the binational water dialogue, the Roadmap includes activities to be accomplished at various levels: (1) local, (2) university, (3) water management agencies, and (4) international. In using it, each basin should assess and take advantage of the experiences and work already under way in that basin in order to address site-specific concerns. Creating a binational water balance as a tool could assist in a better understanding of the regional basin, as well as to assure its longevity.

As the text box highlights, the Rural Task Force's Mimbres Basin Dialogue developed a roadmap to help direct its efforts.[34] Most of these activities have been possible because the key implementers have been successful in obtaining Border 2012 funds to carry out these projects. The Ecological Issues Subcommittee met with SEMARNAT to agree to develop an *ordenamiento ecológico* for the *municipio* of Janos. Ecological Issues Subcommittee members, The Nature Conservancy, and Pronatura announced the acquisition of Rancho El Uno for conservation purposes. These same members facilitated signing a letter of intent to develop an action plan to protect grassland ecosystems in the state of Chihuahua, which was supported by the Task Force. The Subcommittee has also collaborated with the Mimbres-Paquimé Connection, the *municipio* of Janos, and others to promote ecotourism.

Perhaps because this region was not a focus of previous border programs, there has been great interest among local stakeholders in getting involved and providing input on priorities under Border 2012 despite the large distances. The Rural Task Force has had a reasonable degree of success with public involvement in setting the goals and objectives, developing its strategic plan, carrying out various activities, and making significant progress toward reaching the goals and objectives. Given the number and breadth of stakeholders involved, along with striving for consensus on the plan activities, we feel comfortable that the plan reflects the priorities and input of the region.

However, participation has waned since 2008, perhaps due to the rise in narco-violence, change in local government administrations, loss of key stakeholders due to the dire economic situation and violence, and/or the often disjointed nature of program grant funding. In evaluating its activities to ensure that it continues to reflect local stakeholders' perspectives, the Rural Task Force decided that taking this opportunity to provide input into the next iteration of border environmental programs would be appropriate.

Observations from the Field

A number of factors pose challenges to public participation in the border program as the Rural Task Force aims to achieve sustainability in the border region. Drawing from its experiences,[35] it has a number of issues and suggestions, many of which have been raised in Border 2012 Regional and National Coordinators meetings.

While buy-in from the 10 border states raised the level of state agency involvement, the Department of Interior and the Department of Agriculture, which had participated in earlier border environmental programs, chose not to participate in Border 2012. Such an absence left a large void as can be seen by the large umbrella of agencies affected, including the Bureau of Reclamation, Bureau of Indian Affairs, Bureau of Land Management, U.S. Geological Survey, U.S. Fish and Wildlife Service, and the U.S. Forest Service. This absence was felt as the Rural Task Force went about completing activities under the strategic plan, as it was more difficult to address some of the conservation issues raised.

Agency responsibilities do not align across the border. For instance, part of SEMARNAT's jurisdiction is to protect natural areas. It can support activities in Chihuahua under the program while the concomitant U.S. agency may not be able to do likewise under Border 2012, other than through alternative mechanisms. Moreover, because the U.S. Department of Transportation and the U.S. Department of Homeland Security are not part of the Border 2012 Program, the Rural Task Force was not able to facilitate issues related to flooding at the ports of entry and port expansion in Columbus-Palomas, even though these issues were brought up by Mexican participants at some of the Task Force's meetings.

Goals and objectives are necessary to direct actions and measure success. However, universal goals may not be fully consistent with local concerns and thus are difficult to implement in site-specific areas.[36] For instance, the Rural Task Force's priority related to the Chihuahuan Desert ecosystem conservation does not match up with any of the goals of Border 2012, essentially ignoring what the local participants chose to include as a top environmental priority of the region. Similarly, water supply and its scarcity are fundamental to the economic and environmental viability of the Rural Task Force region.[37] Concerns have been repeatedly raised about administration and conservation, which are not specific goals and objectives of Border 2012. As water quantity is fundamentally intertwined with water quality, the Task Force was able to address some of the concerns. However, there is no institutional framework for including the additional necessary agencies in the Border 2012 Program, nor is there funding available to address such concerns.

Media-specific task forces, such as the Border 2012 Water Task Force for the New Mexico-Texas-Chihuahua Region, could provide technical support for geo-specific task forces. Without water supply being a specific goal and many U.S. federal agencies not participating, it is more difficult to obtain such support. Policy forums, such as that for water, could also provide more assistance, but there is no formal structure to obtain it. While such issues have been raised in the regional and national coordinators meetings, no changes have been made.[38] These are critical needs if geo-specific task forces are to address their priorities.

Although public participation-related outputs, such as number of meetings, number of participating stakeholders, number of stakeholders trained, and number of public comments received are tracked by EPA grantees and the program overall, no specific public participation goals have been defined or formal indicators for measurement of public participation developed. As noted by Mumme in 2010, "it is regrettable that Border 2012's recently updated *Strategy for Indicator Development* makes no provision for assessing public participation in Border 2012 programs."[39]

Minimal guidance is given to co-leaders of the task forces and workgroups for public participation in the Border 2012 Program. Task forces and workgroups are required to announce meetings to the public with 30 days notice; solicit public input on task force priorities; disseminate program information to task force participants; and conduct annual reporting. However, no training or guidance is given to co-leaders on how to engage the public on setting priorities and ensuring that all stakeholders are involved in the process. Border partners implementing the program at the local level also need training on how to ensure effective public participation.

Border 2012's emphasis on measurable results is important yet it overlooks the necessary steps of coordination of binational groups and planning related to achieving Border 2012 goals and objectives. Annually, a request is sent out by EPA for proposals to achieve these programmatic goals, but they do not necessarily dovetail with the local ones. Clearly, the strategic plan provided a framework for Rural Task Force activities and a way to show progress and update projects. Border 2012 provided funding to the Rural Task Force to develop its strategic plan; however, this appears to be the exception rather than the rule for most task forces.

Part of meeting the goals of the task forces and regional workgroups is coordination of the group. While this is an activity for which it is hard to measure results, except in the negative, it is a critical ingredient for any effective binational program and for public participation. Coordination is needed to obtain and maintain public involvement in the border program. Co-leaders serve this coordination role and provide information to local stakeholders on projects, organize meetings to obtain public input and participation, notify local stakeholders of grant opportunities and other Border 2012 meetings such as regional workgroup and national coordinators meetings, and oversee the implementation of the task force's strategic plan. With few exceptions, coordination is not a funded task and, therefore, results may vary across the border in terms of keeping groups on track, moving forward to meet goals, and ensuring public participation in the process.

Border 2012 has improved communication among stakeholders, authorities, and the community at large. However, language continues to be a barrier, not only in the discussion of environmental matters but for border communities in Mexico and the U.S. While important to take into account, it is often not possible to count on simultaneous interpretation at each meeting of each task force. BECC provides annual meeting support to task forces that includes interpretation services. For any additional meetings, task forces are on their own to provide this service.

Local government participation from the Mexican side is often difficult. Budgets for local government officials do not allow for investment in public health and the environment, nor is there the expertise at the local level to address such issues. As a result, local officials feel it is a federal government duty to address these needs.

More involvement from the community continues to be a need. Community leaders enter and leave the process over time. There is a constant need to educate communities on the Border 2012 Program, including issues and accomplishments, and on new issues as they emerge.

The presence of border NGOs has significantly declined over the past 15 years and poses a major barrier to public participation. Lack of funding and capacity has reduced NGO involvement in the border program.

Rural Task Force stakeholders have identified the need for more environmental education activities throughout the year and more community-based projects to raise environmental awareness. These projects include activities such as tree planting, community gardens, community trash and scrap tire cleanups, and water conservation fairs.

The impacts of climate variability in the border region pose a major challenge to public participation. As indicated previously, the Border 2012 Program is still too reactive and does not sufficiently plan for the future in the binational context. As climate impacts water availability and shared water resources become more stressed, border communities need institutions that can plan effectively while ensuring that the public is involved in the decision-making process. It is difficult to get effective public participation when in crisis mode and many of the potential solutions are no longer viable.

The rise in narco-violence has prevented many U.S. federal and state government agencies from participating in border meetings and events that take place on the Mexican side of the border. In the Rural Task Force region, this violence has resulted in the death of at least one border partner and contributed to the relocation of many other active stakeholders from the border region. Violence has a chilling effect on participants, thus affecting implementation. It is difficult or impossible to implement a program at the local level when those involved are fearful and do not feel safe in carrying out projects.

Increased U.S. federal security efforts have neglected to fully involve local stakeholders in homeland security projects because of the waiving of environmental and other laws. The failure to include local input when constructing the border fence has caused distrust between border residents and the U.S. federal government. Border communities are left to bear the environmental impacts of these activities, such as increased emissions from longer wait times at the ports of entry, flooding and other hydrologic problems, or destruction of natural and cultural resources.

The downturn in the economy underscores the tension between the short-term need to earn a living and the long-term need to ensure sustainability for the future. The drive for a new and green economy cannot ignore potential impacts across the border. Consistent with the goals of Border 2012 to promote sustainable development in the border region, economic development needs to be balanced with environmental and social considerations. No mechanism for achieving this exists in the border region. If a project is conducted with BECC or NADB funds, then an assessment of the project's environmental impacts is required. However, there is no requirement for assessment of transboundary environmental impacts of projects outside of this BECC-NADB process. Thus, projects can be constructed in the border region without assessment of transboundary impacts, as well as without public input from the affected communities on the other side of the border.[40]

A number of border projects and programs currently exists that lack obvious coordination.[41] For instance, in September 2009, the Ten States Border Governors adopted "Guidelines for the Competitive and Sustainable Development of the U.S.-Mexico Transborder Region."[42] While the guidelines state that "an important goal of this Border Governors Conference is to successfully build on past efforts and to sustain and lend continuity to earlier achievements," no mention is made of the Border 2012 Program, which was not only agreed to by EPA and SEMARNAT but by all 10 border states.[43] Public participation is not clearly developed in the guidelines, setting up potential conflicts in programs and expectations.[44] The U.S. Department of Transportation's Federal Highway Administration interacts with the Mexican Secretariat of Communications and Transportation (Secretaría de Comunicaciones y Transportes–SCT) in the U.S.-Mexico Joint Working Committee (JWC), a binational group whose primary focus is to cooperate on land transportation planning and the facilitation of efficient, safe, and economical cross-border transportation movements. While state transportation agencies are represented in the group, it is not clear if there are processes in place for further public engagement.[45]

Examples to Consider

The aforementioned observations are meant to call attention to some of the disconnects between the Border 2012 Program as written and/or as implemented, and some of the deficiencies in the program as it strives to create a robust public participation program and achieve its mission. We do not want to leave the impression that only problems exist. As with the New Mexico-Chihuahua Rural Task Force, within and without Border 2012, there are numerous examples of how public participation is resulting in improved binational environmental discussions and actions. The following are presented as potential examples to consider when designing the next version of the U.S.-Mexico border environmentl program.

The handbook, *Environmental Enforcement in the U.S.-Mexico Border Region*,[46] suggests how a community might utilize the current Border 2012 Program, as indicated in the text box:

Community Participation in Border 2012 Enforcement Activities

Border 2012 emphasizes a "bottom-up approach." It is one possible mechanism for community residents to address their concerns about environmental enforcement generally, or about a specific polluting facility. As with any of the strategies discussed in this handbook, however, it is important to consider the *limitations of the process*. Border 2012 will not be an effective vehicle for addressing every individual environmental justice problem. Results may be hard to achieve because of: (1) the limited resources of the Border 2012 Program to address an enormous array of border environmental problems; (2) the confidential and politically-sensitive nature of cross-border enforcement actions; and (3) the large amount of time and resources that community residents may need to invest to pursue action under Border 2012.

Nevertheless, the formal Guiding Principles of the Border 2012 Program—founded in the La Paz Agreement—emphasize community participation and include the following:

- Improve stakeholder participation and ensure broad-based representation from the environmental, public health, and other relevant sectors;
- Foster transparency, public participation, and open dialogue through provision of accessible, accurate, and timely information;
- Strengthen capacity of local community residents and other stakeholders to manage environmental and environmentally-related public health issues.[14]

As with all processes described in this handbook, if the community is well organized, the chances of being effective are much greater. As part of their broader organizing activities, community residents may want to learn more about current Border 2012 activities, provide input about those activities, and raise new issues for the program to address. For example, if a community is concerned about a particular facility that may be violating the law and endangering public health, residents may want to raise the matter with the Regional Task Force that deals with enforcement in that particular part of the border. Following are some of the ways that community residents can try to become involved in the Border 2012 Program.

[14] U.S.-Mexico Border 2012 Framework, *available at*: http://www.epa.gov/border2012/intro.htm

Source: Environmental Law Institute and Southwest Network for Environmental and Economic Justice 2007, pp. 92, 94, http://www.elistore.org/Data/products/d17_11.pdf.

The *Metales y Derivados* cleanup is one of the best examples of the importance of community-based pressure to resolve local environmental problems.[47] The following text box describes the process through 2009. Since then, work on the site has been completed and a community recreation site has been built there.

Border 2012 and the Cleanup of *Metales y Derivados**

Metales y Derivados was a secondary lead smelter and battery recycling facility located in Tijuana. In 1994, the Mexican government ordered the facility closed for environmental violations. The U.S. owner abandoned the site and fled back to the United States, leaving behind thousands of tons of soil contaminated with lead and other heavy metals. It has been widely recognized that these abandoned hazardous wastes pose an ongoing threat to the health of neighbors in the Colonia Chilpancingo. The CEC recognized these problems in its 2002 Factual Record, described in the preceding section. Since the time the facility was abandoned, residents of the Colonia and other activists have organized and advocated for the governments to take action to clean up the site.

Finally, after many years of pressure from the environmental justice community on both sides of the border, and years of binational discussions, there has been significant progress. In 2004, several Mexican government agencies—federal, state and local—signed an Agreement of Coordination for the cleanup of the Metales site. The Agreement, consistent with Border 2012's goal of "Reducing Land Contamination," established a four-phase remediation program: (1) risk reduction; (2) site characterization and risk assessment; (3) alternative analysis and selection of remedy; and (4) carrying out the selected remedy.

This Agreement was not the only one signed by the government in 2004. At the same time, the federal and state environmental agencies signed a landmark Agreement of Collaboration *with community residents*. The Agreement established the participation of the community in the *Metales* cleanup project by creating a Workgroup. In addition to federal and state officials, the Workgroup includes the Environmental Health Coalition of San Diego and its Tijuana affiliate, the *Colectivo Chilpancingo Pro Justicia Ambiental,* whose members are residents of [the] Colonia. This is the first time that a Mexican border community has been formally included in a technical workgroup responsible for overseeing the planning and cleanup of a site. An important aspect of the Workgroup is that it operates by consensus. The Workgroup has held some of its formal sessions in the Colonia itself.

The cleanup project is to be completed by 2009. So far, Phases One and Two are complete, and approximately 2,000 tons of waste have been removed from the site. The Mexican government has contributed about $750,000 toward the cleanup. The U.S. government provided $85,000 for initial, short-term actions to address the highest risks, as well as additional funds for technical consultants. The workgroup is currently working on Phase Three—selecting the remedy—before moving on to the Phase Four remediation.

Sources: Environmental Health Coalition: www.environmentalhealth.org
Border 2012 Program Regional Workgroup Newsletter: http://www.epa.gov/border2012/pdf/ca_baja_news2_eng.pdf

Sources: Environmental Law Institute and Southwest Network for Environmental and Economic Justice 2007, p. 93, http://www.elistore.org/Data/products/d17_11.pdf

The National Coalition for Dialogue and Deliberation (NCDD) provides guidelines for moving along the public participation spectrum toward public engagement, as their Core Principles illustrate:[48]

Core Principles for Public Engagement

1. Careful Planning and Preparation
   Through adequate and inclusive planning, ensure that the design, organization, and convening of the process serve both a clearly defined purpose and the needs of the participants.
2. Inclusion and Demographic Diversity
   Equitably incorporate diverse people, voices, ideas, and information to lay the groundwork for quality outcomes and democratic legitimacy.
3. Collaboration and Shared Purpose
   Support and encourage participants, government and community institutions, and others to work together to advance the common good.[1]
4. Openness and Learning
   Help all involved listen to each other, explore new ideas unconstrained by predetermined outcomes, learn and apply information in ways that generate new options, and rigorously evaluate public engagement activities for effectiveness.
5. Transparency and Trust
   Be clear and open about the process, and provide a public record of the organizers, sponsors, outcomes, and range of views and ideas expressed.
6. Impact and Action
   Ensure each participatory effort has real potential to make a difference, and that participants are aware of that potential.
7. Sustained Engagement and Participatory Culture
   Promote a culture of participation with programs and institutions that support ongoing quality public engagement.

[1] In addition to reflecting democratic ideals of liberty, justice, and freedom for everyone, "common good" refers to that which benefits all, like a traffic light in a dangerous intersection or a cleaned-up water supply.

An example of public participation is the group working with the U.S.-Mexico Transboundary Aquifer Assessment Program (TAPP) in Arizona, as indicated in the following Fact Sheet:[49]

FACT SHEET: U.S.-Mexico Transboundary Aquifer Assessment Program - Arizona (TAAP-A/S)

Aquifers shared by Arizona and Sonora
Version: November 2, 2010

Progress and Future Activities

- Definition of TAAP-A/S work plan among binational stakeholders
- Public engagement/awareness of the TAAP-A/S through presentations at conferences and community meetings.
- Compilation of scientific and other published materials in a searchable, online, bilingual database on groundwater resources within the binational Santa Cruz and San Pedro valleys.
- Initial stages of contaminant transport modeling and building of hydrogeologic framework model in the Santa Cruz
- Initial recharge / runoff monitoring and modeling in the San Pedro.

TAAP-A/S Collaborating Partners

- <u>Mexico</u>: Comisión Nacional del Agua; Comisión Estatal del Agua-Sonora (Unidad Cananea); OOMAPAS-Nogales; Universidad de Sonora; Colegio de Sonora; Instituto Tecnológico de Sonora
- <u>United States</u>: Bureau of Reclamation; Arizona Department of Water Resources; City of Nogales, Arizona; Friends of the Santa Cruz River, Upper San Pedro Partnership
- <u>Binational</u>: International Boundary and Water Commission; Water Committee of the Arizona-Mexico Commission

Timeline and Selected Accomplishments

- August 19, 2009 - U.S. and Mexico Commissioners of IBWC formally approved Joint Report of the Principal Engineers regarding the Joint Cooperative Process United States-Mexico for the Transboundary Aquifer Assessment Program.
- November 3-4, 2009 - TAAP-A/S sponsored workshop "Developing a Work Plan for the Assessment of the Santa Cruz and San Pedro Aquifers" held in Tucson, Arizona. [Presentations can be found at http://www.cals.arizona.edu/azwater/taap/]

Recommendations

As many astute observers have noted, Border 2012 represents a quantum leap forward from the top-down arrangements of the past. As the next iteration of border programs are being discussed, public participation should be expanded. Mumme has pointed out, however, that the opposite is occurring.

> Clearly, the gains of the 1990s are no basis for complacency where citizen participation in border environmental governance is concerned. In my view it is time for a renewed scholarly effort to appraise these developments. Scholars need to identify obstacles to improved public participation and support NGO's and civil society's efforts to make participation more inclusive, more effective, and more meaningful in border environmental management.[50]

Baja California Environmental Secretary Sócrates Bastida Hernández also raised relevant comments and questions regarding the future of Border 2012 at the National Coordinators meeting in 2009:

> It would be advisable to put on the agenda of the succeeding program, goals and indicators designed to fulfill the legitimate aspiration of this binational and transborder region of achieving environmental sustainability at the same time and in the same order of importance as it achieves social and economic development. ... What role should the succeeding program play as regard to a green or conservation agenda? ... Which are the principles, objectives and goals that must be included in the succeeding program in order to meet Border 2012's mission as regard to social and economic development that conserves and uses resources in a sustainable manner?... Additionally, we should ask ourselves, what is the role of the state governments going to be? ... Another important aspect is Border 2012's structure, operability and communications. In this regard, we believe that it is necessary to pay attention to developing a program agenda with transversal objectives, which would have to undergo a review as to the intercommunication within the workgroups, whether they are regional, borderwide, or local. ... We end this presentation with the certainty that the analysis and construction of the succeeding program must be conducive to strengthening the management

> capacity of local governments, who will have to take on more of a leadership role in managing and planning actions that will have the greatest impact in reducing the border's problems.[51]

As potential remedies for the issues discussed previously, we have several recommendations of possible ways to bolster public participation in a border environmental program. These are:

Establish indicators of public participation for the Border 2012 Program. The Border 2012 Program does not formally evaluate public participation and thus it is difficult to determine the effectiveness of public participation efforts within the task forces, workgroups, and policy forums. The only way to measure success of the program regarding public participation and to track progress toward this goal is to develop indicators. The Border 2012 Indicators Group should establish indicators of public participation for the border program.

Formally evaluate public participation in Border 2012 and assess the needs for grassroots participation. EPA and SEMARNAT should collect and analyze available public participation data, as well as conduct surveys of co-leaders and stakeholders alike to determine what may be needed to improve public participation.

Transition more fully from public outreach and involvement to public collaboration and engagement and establish public engagement guidelines in the Border 2012 Program. In order to have full public participation in the border program, we suggest that EPA and SEMARNAT pursue implementation of models of public collaboration and engagement. Border 2012 envisions local stakeholders participating in environmental priority setting and developing solutions to these issues. This is more of a public collaboration and engagement activity as opposed to public involvement (see Table 2). EPA and SEMARNAT should formalize guidelines for task forces, workgroups, and policy forums to follow in order to standardize public engagement throughout the border region.

Local task force support. Local task force coordinators should be supported with funding in order to ensure that the public participation objectives of the border program are carried out. Task force co-leaders should be trained in public participation and provided with guidelines on how to ensure public participation in the border program.

Community outreach and education. Border stakeholders have indicated that more community outreach and education are needed, especially on emerging issues. One stakeholder has suggested that the program experiment with the *promotora* model as a means to more broadly educate border communities on important issues. Outreach to local government officials in some areas is needed to obtain their participation in the border program.

Structural recommendations. In order to more effectively address the goals and objectives of the border program at the local level, more formal connections and definition of roles and responsibilities among workgroups and task forces need to occur. Borderwide workgroups and policy forums need to provide technical assistance to local task forces that do not always have the technical expertise to deal with a particular issue or that require federal-level involvement.

The next iteration of the border program should include ecological goals and objectives and involve the relevant U.S. federal agencies (i.e., DOI, USDA) that cover land management issues.

By incorporating Department of Homeland Security into the Border 2012 Program, security infrastructure planning can be folded into the border program to ensure that potential environmental and other impacts are dealt with and mitigated in a more comprehensive fashion.

Because environmental concerns need to be balanced with social and economic issues to achieve sustainability in the border region, the border programs should consider integration with economic development efforts. For example, ecotourism holds promise as a vehicle to achieve ecological conservation while at the same time providing economic development to local communities. Also, educating local communities and officials about the connections between environmental quality and economic development is an important step. The Border Governors have outlined some goals and objectives for economic development in the areas of energy efficiency and green chemistry that may offer opportunities for collaboration with the border program.

Using the JAC as a model, appointing to task forces representatives from various sectors may formalize participation from stakeholders and thus ensure representation from a cross section of the community.

Planning recommendations. Border 2012 has still not become a pro-active rather than reactive program. Developing joint, geo-specific and/or media-specific strategic plans is one way to fully involve the public in priority setting and development of solutions. The plans are also a useful tool to track progress to meeting goals and objectives and as a framework for public engagement in the work of the task force or workgroup. Strategic plans are a means to define with community participation a vision for sustainable development at the local level and determine the steps that need to be taken to achieve that vision. Climate adaptation related to water supply is an area in which border communities must engage in joint planning. The BECC has been working on this and we encourage development of joint planning methodologies.

A transboundary environmental impact assessment (TEIA) is critical to ensuring that border communities have input in border projects with the potential for transborder impacts. Passage of TEIA should be a priority for the U.S., Mexico, and Canada.

Conclusion

Under the La Paz Agreement, the United States and Mexico agreed to protect, conserve, and improve the environment of the border region. The agreement created a framework for the two governments to resolve environmental issues along the border. The Border 2012 Program is the current iteration, but contemplation as to what might be changed in the next version is timely.

Public participation in border environmental decision making has been strengthened since the signing of the La Paz Agreement in 1983. Incorporating input from border stakeholders, the latest implementation program—Border 2012 Program—reflects partnerships with border states and tribes and is based on priority setting and implementation at the local level. While moving in the right direction toward creating a sustainable future, there are several disconnects, some of which have been addressed.

Despite these improvements to involve border stakeholders, the program warrants improving as EPA, SEMARNAT, and their border partners contemplate the next iteration of the program. EPA and SEMARNAT should establish indicators and guidelines for public participation and train co-leaders in how to facilitate public participation in task force implementation. The border program needs to support more community outreach and education, make some structural changes to more closely align goals and objectives from the programmatic level to the task force level, and include agencies that have not participated in Border 2012 but are integral to achieving sustainability in the border region. These agencies include the Department of Transportation, Department of Homeland Security, Department of Agriculture, and Department of the Interior. Finally, strategic planning at the local level is needed to ensure public participation in priority setting and development of solutions to the border's environmental concerns.

ENDNOTES

[1] *Participatory Governance and the Millennium Development Goals (MDGs)*. Publication based on the Expert Group Meeting on Engaged Governance: Citizen Participation in the Implementation of the Developmental Goals including the Millennium Development Goals (MDGs) 1–2 November 2006. New York. http://unpan1.un.org/intradoc/groups/public/documents/UN/UNPAN028359.pdf.
[2] http://www.peopleandparticipation.net/display/Involve/Home.
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[4] International Association for Public Participation. http://www.iap2.org/displaycommon.cfm?an=4-.
[5] Dietz, Thomas, and Paul C. Stern, editors, *Public Participation in Environmental Assessment and Decision Making*, 2008, Washington, D.C.: The National Academies Press. http://www.nap.edu/catalog.php?record_id=12434. "Until now there have been few attempts to synthesize this diverse literature (on public participation) and draw out conclusions and recommendations for practice. To provide such a synthesis was the objective of the U.S. National Research Council convened Panel on Public Participation in Environmental Assessment and Decision Making. In their book *Public Participation in Environmental Assessment and Decision-Making*, edited by Thomas Dietz and Paul Stern, the Panel presents the outcomes of an extensive

process of research and consultation involving a series of workshops, meetings, and working papers bringing together academic and practitioner expertise pertaining to public participation. *Public Participation* is the culmination of this process and, as such, is perhaps the most comprehensive review to date of this field." Lorraine Whitmarsh, November 2009, *Environmental Science & Policy* 12 (7): 1069–1072, http://www.sciencedirect.com.

[6] http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=78&ArticleID=1163.

[7] http://www.unece.org/env/pp/documents/cep43e.pdf.

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[11] Mumme, 2010.

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[14] Barry and Sims, p. 74.

[15] *U.S.-Mexico Border XXI Program: Progress Report 1996–2000.* EPA 160/R/00/001 p. 2. Published by EPA and SEMARNAP.

[16] Mumme, 2010.

[17] Barry, p. 76.

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[19] *U.S.-Mexico Border XXI Program: Progress Report 1996–2000*. EPA 160/R/00/001 p. 9. Published by EPA and SEMARNAP.
[20] EPA and SEMARNAP, p. 7.
[21] EPA and SEMARNAP, p. 2.
[22] EPA and SEMARNAP, p. 3.
[23] EPA and SEMARNAP, p. 10.
[24] EPA and SEMARNAP, p. 10.
[25] EPA and SEMARNAP, p. 13.
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[29] Mumme, 2000.
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[31] U.S.-Mexico Environmental Program: Border 2012 Implementation and Mid-Term Report: 2007.
[32] Sixth Meeting of the National Coordinators, Minutes of the Future Binational Program Discussion Session. October 28, 2009, Valley Center, CA, EPA Region 9.
[33] Sixth Meeting of the National Coordinators, October 28, 2009.
[34] Presented at the Border Institute VIII, "Discovering Means and Mechanisms for Collaborative Planning and Operation of Transboundary Watersheds." Rio Rico, AZ, May 22–24, 2006. www.scerp.org/bi/bi-viii/Mimbres%20Roadmap%20short.ppt The current version can be found at http://border.nmsu.edu/rtf_documents/Roadmap_Proposal_updated.doc.
[35] While the authors are responsible for these recommendations, they are enhanced by comments from participants and responses to a survey of Border 2012 Task Force members about their experiences with Border 2012. The survey was done in January 2010 by the authors and although the responses were few, the input was valuable and is included along with comments from participants in the text.
[36] "If there is one thing that we have learned after over a decade of transborder work, it's that local solutions to local problems are usually better than one size fits all, top-down prescriptions." Rick

Van Schoik and Erik Lee, *The Border Governors Conference: (Still) Only Part of the Solution*, September 1, 2009. http://nacts.asu.edu/border-governors-conference-still-only-part-solution.

[37] "Water scarcity is undoubtedly the greatest single environmental peril in the U.S.-Mexico transborder region. It threatens our quality of life, endangers water-sensitive ecosystems and the wildlife they support, puts at risk economic growth, and strains diplomatic relations between the two nations." Ten States Border Governors recently adopted Guidelines for the Competitive and Sustainable Development of the U.S.-Mexico Transborder Region.

[38] As air and water are ignorant of political boundaries, binational policies are needed to address their protection. Each country has enforcement measures, but they are unilateral. The Joint Advisory Committee, created to address air quality in the Paso del Norte region, provides a good example of how policies might be developed to address noted problems. The IBWC/CILA works together on surface waters by implementing treaties, but has thus far been reluctant to take on a similar role with respect to groundwater, perhaps due to the lack of a treaty. Potentially, IBWC/CILA has jurisdiction over groundwaters close to the international limit under Section 6 of Minute 242 (1973): "With the objective of avoiding future problems, the United States and Mexico shall consult with each other prior to undertaking any new development of either the surface or the groundwater resources, or undertaking substantial modifications of present developments, in its own territory in the border area that might adversely affect the other country."

[39] Mumme, 2010.

[40] A recent example: as a part of the Integrated Biorefinery Program, Sapphire Energy has been awarded a $50 million grant and $54.5 million loan to construct and operate a full scale algal biofuels production center approximately ten miles from Columbus, NM, and less than a mile north of the border. Many concerns have been raised about the viability of algal biofuels (see for example, "Environmental Life Cycle Comparison of Algae to Other Bioenergy," Andres F. Clarens, Eleazer P. Resurreccion, Mark A. White, and Lisa M. Colosi, University of Virginia, January 2010, http://pubs.acs.org/doi/pdfplus/10.1021/es902838n). In addition to concerns as to the project's environmental footprint and water usage, no consultation has to date

occurred with Mexican officials or the public in the region. Given the proximity to the border, would Section 6 of IBWC's Minute 242 require such? How do such projects fit within the Border 2012 framework?

[41] "A multitude of plans and programs exists that should be implemented to advance the region's infrastructure, as well as the institutional and social changes proposed in these Strategic Guidelines. In preparing the report, several federal, regional, state, and local plans and programs surfaced, all promoting economic integration through more secure trade, sustainability, and a better quality of life. There are also numerous efforts led by private-sector organizations that support the same principles and strategies embraced by the Strategic Guidelines. All these plans and programs, public and private, short term and long term, should be implemented because they contribute directly to the strengthening of the transborder region." 5.1. Implementing the Strategic Guidelines through Existing Development Plans and Programs, Strategic Guidelines for the Competitive and Sustainable Development of the U.S.-Mexico Transborder Region (nonbinding document), September 2009, http://bordergovernors.org/en/pdf/Strategic_Guidelines_ENG.pdf.

[42] Implementing the Strategic Guidelines through Existing Development Plans and Programs, Strategic Guidelines for the Competitive and Sustainable Development of the U.S.-Mexico Transborder Region (nonbinding document), September 2009. During this year's XXVIII Border Governors Conference (BGC) held in Monterrey, Nuevo León, an important border policy vision was developed and unveiled to create a framework on how to conduct business in the border region. The Strategic Guidelines delivered policy initiatives under four key policy areas: Competitiveness, Sustainability, Security, and Quality of Life. The 13 BGC Work Tables will be tasked in developing substantial policy actions under these four policy areas. Noteworthy is that the Border Legislative Conference is also working on similar issues, but is not necessarily coordinating with the BGC, although as set out in their Resolution from the November 2009 meeting, the aim is to do so, as well as to coordinate with Border 2012 efforts on scrap tires. http://www.borderlegislators.org.

[43] As an interesting aside, the Ten States "ironically gelled out of concerns about being excluded from the Border XXI Program." Good Neighbor Environmental Board, Assessment of the Border XXI Program. Addendum 1 to the U.S.-Mexico Border XXI Program: Progress Report 1996–2000.

[44] "Transborder development requires coordinated action among various actors on both sides of the border. Traditionally, transborder government was conceived of as intergovernmental principally among federal agencies in order to solve shared security, health, and environmental problems. Currently, fiscal problems and the lack of effectiveness of traditional tools to confront complex border problems have overwhelmed the region's state and local governments. In the context of the growing binational interdependence between Mexico and the United States, we cannot regulate the issues of security or environmental protection only at the national level or through traditional intergovernmental cooperation. Several key characteristics distinguish the government structure's current reality and are needed for the implementation of the Strategic Guidelines:

- Flexible and integrated networks, including public-private associations and citizen coalitions. These networks must complement government action and, on occasion, occupy spaces where the government cannot effectively intervene.
- Public and private universities must play a significant role in establishing these networks and maintaining a position of leadership in their functioning.
- We must recognize the role that NGOs and other citizen initiatives play in noting when issues arise and advocating for government intervention and action at the earliest stages of these problems.

Since the Strategic Guidelines largely encompass innovative policies and actions, the participation of nongovernmental networks during their implementation is broadly recommended. In the context of a global strategy, these networks can exercise at least three key functions:

- They can convene and bring to the table all the actors, mobilizing key districts and offering a forum for exchange of points of view. The universities on both sides of the border have demonstrated success in playing this role.

- They can act as neutral third parties during the policymaking process, particularly during the negotiation of controversial issues, such as sharing natural resources and land-use administration.
- They can act as transborder advocates, pressuring governments to incorporate transborder aspects into their planning and policies." 5.4.3. Civil Society Organizations working toward a competitive and sustainable transborder region, Strategic Guidelines for the Competitive and Sustainable Development of the U.S.-Mexico Transborder Region (nonbinding document), September 2009, http://bordergovernors.org/en/pdf/Strategic_Guidelines_ENG.pdf.

[45] http://www.borderplanning.fhwa.dot.gov. Another way for public members to become confused is when apparent overlaps exist. See for instance, "The Greening of the Border" conference of the JWC (U.S.-Mexico Joint Working Committee [JWC] Meeting Minutes Santa Fe, NM, July 13–15, 2009," and the "Greening Borders: Cooperation, Security and Diplomacy," University of San Diego, November 18–20. 2009. http://www.sandiego.edu/peacestudies/documents/ksps/english_agenda.pdf.

[46] *Environmental Enforcement in the U.S./Mexico Border Region: A Community Guide to Enforcement in Texas and Chihuahua*, August 2007. Download this report for free. http://www.elistore.org. Community Environmental Law Initiative, a joint effort between the Environmental Law Institute and the Southwest Network for Environmental and Economic Justice. The preparation and publication of this handbook was supported by the U.S. Environmental Protection Agency Region 6. "The handbook provides practical information about the tools for community participation in environmental enforcement, describing legal tools in the U.S. and Mexico, as well as binational mechanisms for promoting effective enforcement. The handbook focuses on the states of Texas and Chihuahua, but provides information about environmental agencies, laws and processes that can be useful to communities throughout the border region. The handbook is available in English and Spanish."

[47] *Environmental Enforcement in the U.S./Mexico Border Region: A Community Guide to Enforcement in Texas and Chihuahua*, August 2007, http://www.elistore.org.

[48] National Coalition for Dialogue and Deliberation, May 1, 2009, http://www.thataway.org/files/Core_Principles_of_Public_Engagement.pdf.

[49] "The TAAP originates from U.S. Public Law 109-448, signed into law by the President on December 22, 2006, as the Transboundary Aquifer Assessment Act. The Act applies to the states of Texas, New Mexico, and Arizona where four transboundary aquifers have been designated for priority assessment; those being the Hueco Bolson and Mesilla Basin aquifers in the greater El Paso/Ciudad Juárez region, and the Santa Cruz and San Pedro aquifers across the Arizona-Sonora border. TAAP is designated to operate for 10 years, with $50 million authorized for appropriation over that time period. Appropriations to date include $500,000 each for fiscal years 2008 and 2009." http://udallcenter.arizona.edu/wrpg/pubs2010/TAAP_factsheet_Nov10.pdf.

[50] Mumme, 2010.

[51] Secretary of the Environmental Protection Department of the State of Baja California to the Border 2012, Plenary Session, Environmental Program's Sixth National Coordinators Meeting, October 29, 2009.

VI

Environmental Services at the U.S.-Mexican Border

Lina Ojeda-Revah and Christopher Brown

Abstract

Ecosystem services, as defined by the Millennium Ecosystem Assessment (2005), are the benefits ecosystems provide for human well-being and can be classified as provisioning, regulating, supporting, and cultural. Provisioning services cover natural resources and products derived from ecosystems and represent the flow of goods. Regulating services are the life-support functions ecosystems provide and are determined by the size and quality of the ecosystem. Cultural services are the non-material benefits obtained from ecosystems such as spiritual and religious significance. Binational watersheds are ideal study areas for the exploration of ecosystem services, because they may function as split plots where many natural variables are similar, but where the contrasting economies and social dynamics may operate differently, imposing divergent pressures on shared natural resources.

In our initial research into ecosystem services on the U.S.-Mexican border, we explored the potential of sustainable landscapes in the region from an ecosystem services perspective. The study employs watershed subareas as the basic areas of analysis, because impacts on these areas sensitive to human activities may affect hydrologic cycles and water availability. Data used are analyzed for each subarea through the use of a spatial pressure index composed of four variables

with the following formula: Urban area + Urban patches + Population - Population density = Pressure index. Data were normalized to each subarea so they could be compared and converted to a value between 0 and 1 to be used in the formula.

The traditional approach for conservation of natural resources is the establishment of natural protected areas. However, other types of land ownership systems also preserve natural resources. Common property regimes such as Mexican *ejidos* offer protection of ecosystem services, as does private land ownership in the U.S. Thus, in this research, we explore the contribution of institutional conservation in the sense of natural protected areas (federal, state, or county) and *ejido* land to the protection of ecosystem services.

To asses our objectives, we used data produced by the U.S.-Mexico Border Environmental Health Initiative (BEHI) on urban and natural protected areas, and by the National Institute for Statistics and Geography (Instituto Nacional de Estadística y Geografía–INEGI) on *ejido* land, within the major subareas (groups of basins) along the U.S.-Mexican border. Our results suggest that approximately 330 natural protected areas cover around 20% of the border subareas. More than 79% of the natural protected areas are on the U.S. side of the border and most of these lie in the western portion of the border. *Ejido* land accounts for almost 40% of the naturally vegetated area of Mexico, including grasslands, and 12.6% of the whole border area. These lands are concentrated mainly in the midwest of the border.

In order to preserve ecosystem services, land-use administration must be taken into account, but this varies considerably between the U.S. and Mexico. Within Mexico, preservation of ecosystem services would benefit from land-use planning that better examines future scenarios, includes more active public participation, and explores the linkages of land-use markets and regulation (natural resource markets are an example of such linkages). Within the U.S., land-use policy should better evaluate public policies and their impacts and focus more on the specifics of implementation and administrative efficiency. An overarching shortcoming to protecting ecosystem services in the border region is that planning efforts in both nations stop at the border and future efforts should explore means by which a more coordinated protection strategy can be advanced. Public agencies in both countries are encouraged to coordinate protection efforts across the border that are warranted. An area with the potential for such integration is the Big Bend region where U.S. efforts toward ecosystem services preservation in the Big Bend National Park could be linked with the emerging conservation efforts in Mexico that seek to protect the Maderas del Carmen, a subregion of the Sierra del Carmen mountain range that lies across the Rio Grande River from the U.S. national park.

INTRODUCTION

Environmental Services: Concept and Importance

Human beings depend on the environment for their survival. The term environmental services refers to: "The benefits human populations derive, directly or indirectly, from ecosystem functions and includes both goods and services" (Lugo 2008), and includes numerous values as detailed in Table 1.

Table 1. Ecosystems Goods and Services

Gas regulation	Waste treatment
Climate regulation	Pollination
Disturbance regulation	Biological control
Water regulation	Refuge for biota
Water supply	Food production
Erosion control	Raw materials
Soil formation	Genetic resources
Nutrient cycling	Recreation and culture

Source: Costanza et al. 1997.

Environmental services are not adequately quantified in commercial markets as economic services and manufactured capital are, so they are usually not considered in public policy decisions (Costanza et al. 1997). Due to the complexity of natural and seminatural ecosystems, it is hard to define the value of a given land use. Thus, the value of environmental services is generally underestimated and is being eliminated in exchange for short-term monetary gain; business practices and public policies ignore their value and focus only on the consumption of resources. As a result, natural capital is being degraded by the use of energy, materials, water, fiber, topsoil, and ecosystems to meet short-term economic gains (Potschin and Haines-Young 2006).

The appropriate balance between the use of land and water resources to improve well-being and the conservation of environmental services is part of the debate between conservation and development (De Fries et al. 2007). Nevertheless, a minimum level of ecosystem conservation is necessary in order to allow the production of ecosystem services. It is crucial that ecosystems do not become stressed beyond the threshold at which irreversible changes occur. The development of policies favoring land-use planning based on environmental services is hindered due to a lack of information being transferred to policy-makers. In addition, short-term economic concerns often treat these services and their underlying physical elements as inputs to productive processes with little thought given to conservation for future use. Also, commonly held and managed resources are often used without taking into account negative externalities associated with their use. This paper seeks to explore these issues and provide information to support needed discussion on ecosystem services.

In 1995, more than 10 million people were estimated to be living in the U.S.-Mexican border region, with annual growth rates of 4.5% (in Mexico) and 2.4% (in the U.S.) expected during the late 1990s (Peach and Williams 2000). More recent estimates by the U.S. Environmental Protection Agency (USEPA) (2011) put current population at approximately 12 million people, the vast majority of it concentrated in 12 twin border cities. This region has been documented as having a wide range of environmental problems (GNEB 2009), but the border region has not been studied previously from an environmental services point of view. Some parts of the border face multiple pressures of human population growth and sparse urbanization, economic development activities and related infrastructure construction, growing traffic across backcountry lands, and expanding demand for water in a water-limited landscape (Morehouse 2008).

Landscape Ecology and Environmental Services: The Importance of Land-Use Planning in the Conservation of Environmental Services

The spatial configuration of land use/land cover is an important variable to examine to understand the functions and processes defining the degree to which landscapes are more or less sustainable in terms of the outputs of goods and services (Blaschke 2006). As noted by Forman and Collinge (1997), "The spatial solution is a pattern of ecosystems or land uses that will conserve the bulk of, and the most important attributes of, biodiversity and natural processes in any region or landscape."

According to Haines-Young (2000), "A sustainable landscape is one in which the sum of the benefits (goods and services) people derive from the landscape are maintained." Spatial quality is conceived as the potential that landscapes have to enhance sustainability in the socioeconomic or ecological spheres. The design of sustainable landscapes consequently implies maintaining or creating that potential. He adds that, "Sustainability should be measured by the change processes active in the landscape." Saunders and Briggs (2002) add that successful sustainable landscapes need to be managed as a whole.

To understand the consequences of change for sustainability, Haines-Young (2000) suggests the use of the concept of "natural capital" as the natural resources and the ecological systems that provide vital life-support services and all economic activities. We posit that this "natural capital" supports the ecosystem services that this paper examines.

Landscape change is determined by the globalizing economy, mostly by the geographical situation and accessibility of places and their networks. The main driving forces are mobility patterns, accessibility, processes of urbanization, decisions affecting large areas, and calamities, all linked to each other. Urban core areas and networks control how the global economy works spatially; these areas concentrate the population and are where the impacts of hazards are most severe (Antrop 2006).

In the context of sustainable development, decisions on landscape change must consider three dimensions that represent function and pattern of landscapes (Leitão and Ahern 2002; Opdam et al. 2006).

These dimensions are: eco-physical (defined by geographical patterns and ecological processes); social (defined by parameters of human perception, land use, and physical and mental health); and economic (defined by the landscape's capacity to produce economic values).

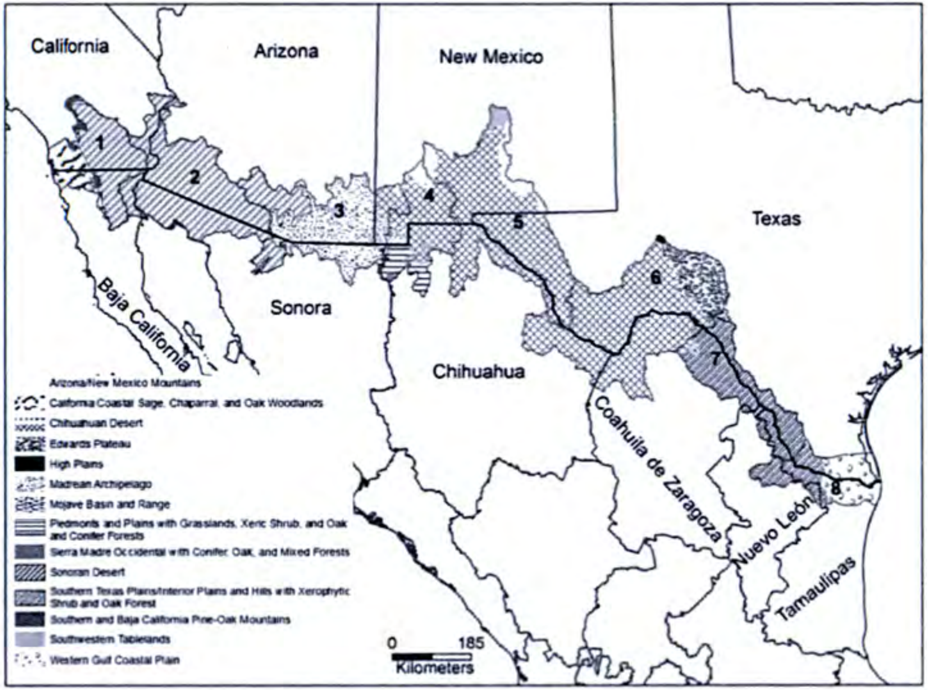
Methods

Binational watersheds are ideal study areas because they may function as split plots where many natural variables are similar, but where the contrasting economies and social dynamics in the U.S. and Mexico may operate differently, imposing divergent pressures on shared natural resources. Using data produced by the U.S. Geological Survey (USGS)[1] on urban and natural protected areas within major subareas (groups of basins) along the U.S.-Mexican border, our research team explored the potential of sustainable landscapes in borderland studies from an ecosystem services perspective. Figure 1 details the USGS subbasins employed in this analysis and also depicts the various ecological regions that exist within each subbasin (USGS 2010; CEC 2006). The study employed watershed subareas as the basic areas of analysis because impacts on these areas sensitive to human activities may affect hydrologic cycles and water availability (Peters and Meybeck 2000). Data used were analyzed for each subarea through the use of a spatial pressure index composed of four variables with the following formula:

Urban area + Urban patches + Population - Population density = Pressure index

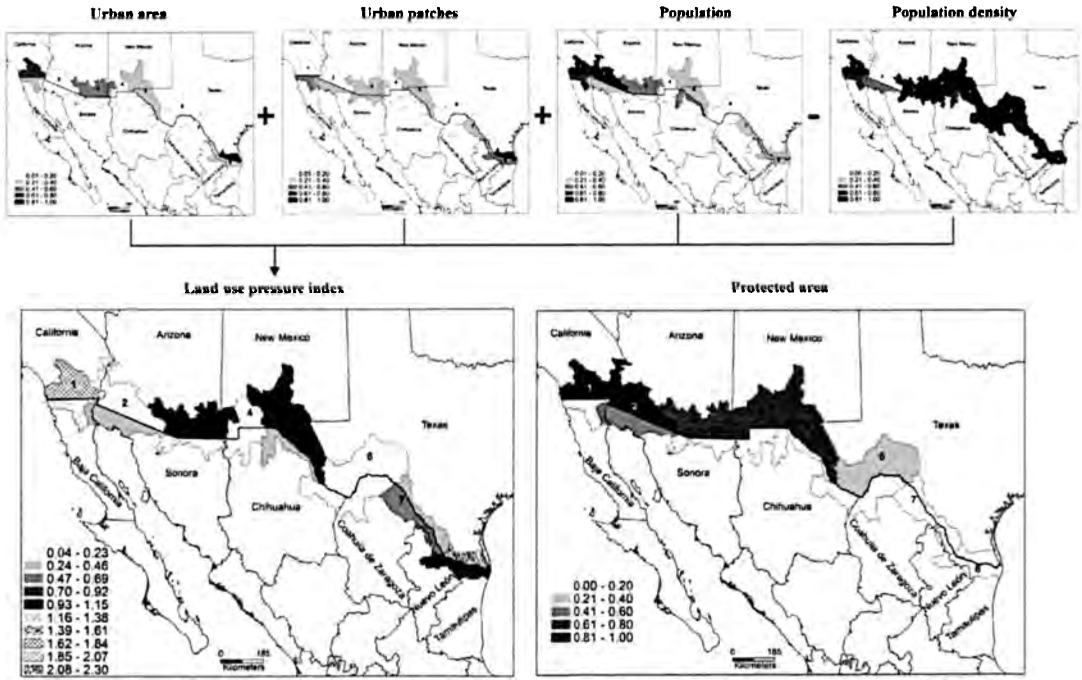
Data were normalized in each subarea so they could be compared and converted to a value between 0 and 1 to be used in the formula. Although not included in the formula for the pressure index, natural protected areas are a strategy used for the conservation of natural resources. Other regimes of land ownership are also employed to preserve natural resources in the U.S. and Mexico, including communally owned land in Mexican *ejidos* and private land holdings in the U.S. Figure 2 details the analysis and also depicts the outcomes across mapped subbasins.

Figure 1. Map of U.S.-Mexican Subbasins and Ecological Regions



Sources: USGS 2010; CEC 2006.

Figure 2. Components of Environmental Services in the US-Mexico Border, Land Use Pressure Index and Protected Area Index



Source: Constructed from data drawn from US Geological Service. U.S. - Mexico Border Environmental Health Initiative. Available at http://borderhealth.cr.usgs.gov/datalayers.html

U.S.-Mexican Ecosystems

Along the U.S.-Mexican border, varied and singular sceneries are shared, with great ecological diversity that results from the juncture of an abrupt topography, the influence of the Pacific and Atlantic oceans, and the confluence of two large biogeographic regions, the Neartic and the Neotropical. The physical geography of the border is dominated by different grades of dryness in which desert shrublands and grasslands prevail. This dryness is interrupted mainly by mountain ranges with moderate and humid climate and with forests of pines and oaks that are flanked by coastal plains. In this region, approximately 85 threatened and endangered species of plants and animals exist, and more than 450 are considered rare or endemic species. More than 700 Neotropical migratory species (birds, mammals, and insects) cross the border habitats during their annual migrations (USEPA and SEMARNAT 1996).

Ecological regions are areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. Ecoregions present at the U.S.-Mexican border as described by the Commission for Environmental Cooperation (CEC 2006) are the following:

1. **Mediterranean Californian.** This region has a Mediterranean-type climate of hot dry summers and cool moist winters; coastal sage, chaparral, and oak woodlands; grasslands in some lower elevations; and patches of pine at higher elevations. Most of the region consists of open, low mountains or foothills, but areas of irregular plains exist in the south. Much of this region is grazed by domestic livestock; very little land is cultivated.
2. **Chihuahuan Desert.** The region comprises broad basins and valleys bordered by sloping alluvial fans and terraces. Isolated mesas and mountains are located in the central and western parts. Vegetation is mainly arid grass and shrubland, and oak-juniper woodlands on the higher mountains.
3. **Madrean Archipelago.** This is a region of basins and ranges with medium to high local relief, from 1,000 to 1,500 meters. Native vegetation is mostly shrub steppe in the basins, oak-juniper woodlands on the ranges, and ponderosa pine in higher eleva-

tions. The region has ecological significance as both a barrier and bridge between the Rocky Mountains and the Sierra Madre Occidental.

4. **Sonoran Desert.** This ecoregion contains scattered low mountains and has large tracts of federally owned land, most of which are used for military training. It contains large areas of desert shrubs, palo verde, cactus, and giant saguaro cactus.
5. **Southern Texas Plains/Interior Plains and Hills.** Xerophytic shrubs and oak forest are the native vegetation. Rangeland and pastureland comprise the predominant land cover. Oil extraction has been a major activity in this region for over eighty years.
6. **Western Gulf Coastal Plains.** This ecoregion has a relatively flat coastal plain topography and is composed of mainly grasslands. Inland, the plains are more irregular and have mostly forest or savanna-type vegetation. A high percentage of the land is cropland. Recent urbanization and industrialization have become concerns in this region.

Components of Environmental Services in the U.S.-Mexican Border

Water Resources

Environmental services and ecosystem conservation in the region depend mainly on the availability of water resources. These water resources include both surface water resources in large river systems (Rio Grande/Río Bravo and Colorado rivers), small river systems (Tijuana, Santa Cruz, and San Pedro), and groundwater resources that lie within binationally shared groundwater deposits or *bolsons*. From a landscape ecology perspective, the areal extent of urban areas, the configuration of urban patches, overall population levels, and population densities are important variables because they reflect the amount of space people use and the spatial pattern of land and water resources being used. A scattered urban area landscape can impact the natural landscape through the dynamics of perforation and fragmentation. All of these variables have ecological implications as they modify or, in some cases, interrupt natural processes such as the natural hydrologic cycle. The protection of natural areas and their role as ecological buffers are just some of the strategies that can be used to protect environmental services.

Urban Area and Population

In 2006, the urban area in the border covered over 6,757.64 km^2 (1.65%) of the total 408,407.03 km^2 of the border subareas. This distribution reflects a difference between countries, as the U.S. contributes 75.88% of the total urban area, dispersed in 113 patches, and Mexico accounts for 24.12% of the urban area, scattered in 95 patches (Tables 2 and 3).

The subareas with greater proportions of urban land use are the Lower Rio Grande Valley (5.80%) and the Pacific Basins-Salton Trough (4.76%). The subareas with the smallest amount of urban land use are in the Rio Grande Basin; Río Conchos to Amistad Reservoir (0.05%), the San Basilio-Mimbres (0.36%), and the Colorado River-Sea of Cortez (0.47%) subareas (Table 2). Although most Mexican border urban areas are larger than those of the U.S., within the border subareas they account for almost 40% of the population.

Regarding population distribution, more than half of the border population (56.31%) is concentrated within the Pacific Basins-Salton Trough and the Colorado River-Sea of Cortez subareas, both in the west. Another 27% exists in the Rio Grande: Elephant Butte Reservoir to above Río Conchos and the Lower Rio Grande Valley subareas, at the edges of the Rio Grande. The Mexican Highlands and the Rio Grande that lies below Amistad Reservoir to Falcon Reservoir subareas account for 15.48% of the population. The San Basilio-Mimbres and the Río Conchos to Amistad Reservoir subareas of the Rio Grande are less populated; they contribute only 1.25% of the border population.

The subarea with the most scattered urban areas is the Lower Rio Grande Valley, with 68 patches, 70% of which are in the U.S. The subareas with the fewest urban patches are the San Basilio-Mimbres and the Río Conchos to Amistad Reservoir subareas of the Rio Grande. The rest of the subareas have between 25 and 31 urban patches.

Table 2. Urban Area and Number of Patches, Population, Population Density, and Protected Area, by Subarea

Subarea	Country	Subarea km²	Urban Area (%)	Urban Patches	Density 2006	Population 2005	Protected Area (%)
Pacific Basins-Salton Trough	U.S.	36,269.25	3.44	9	2.47	3,084,974	29.23
	Mexico		1.23	22	5.36	2,409,938	0.08
	Total		**4.67**	**31**	**3.23**	**5,494,912**	**29.31**
Colorado River-Sea of Cortez	U.S.	58,599.81	0.26	8	20.95	3,249,938	28.23
	Mexico		0.20	14	9.15	1,069,785	16.60
	Total		**0.46**	**22**	**15.88**	**4,319,723**	**44.83**
Mexican Highlands	U.S.	56,452.90	2.02	15	1.19	1,356,120	22.33
	Mexico		0.14	11	4.19	324,869	0.18
	Total		**2.16**	**26**	**1.38**	**1,680,989**	**22.51**
San Basilio-Mimbres	U.S.	32,227.67	0.18	3	0.93	55,274	20.61
	Mexico		0.17	4	1.56	86,469	
	Total		**0.35**	**7**	**1.24**	**141,743**	**20.61**
Rio Grande: Elephant Butte Reservoir to above Río Conchos	U.S.	75,838.75	1.38	19	0.94	983,035	19.56
	Mexico		0.40	6	4.39	1,328,343	
	Total		**1.78**	**25**	**1.71**	**2,311,378**	**19.56**

Table 2. *(continued)*

Subarea	Country	Subarea km²	Urban Area (%)	Urban Patches	Density 2006	Population 2005	Protected Area (%)
Rio Grande: Río Conchos to Amistad Reservoir	U.S.	88,868.85	0.02	5	1.61	22,928	6.14
	Mexico		0.03	3	1.10	25,054	5.10
	Total		**0.05**	**8**	**1.29**	**47,982**	**11.24**
Rio Grande: Below Amistad Reservoir to Falcon Reservoir	U.S.	33,475.08	0.86	7	1.11	321,549	0.08
	Mexico		0.81	14	2.66	721,432	0.05
	Total		**1.67**	**21**	**1.86**	**1,042,981**	**0.13**
Lower Rio Grande Valley	U.S.	26,674.72	4.38	47	0.96	1,118,392	3.31
	Mexico		1.25	21	3.71	1,239,109	5.58
	Total		**5.63**	**68**	**1.57**	**2,357,501**	**8.89**
	Grand Total	**408,407.03**	**1.65**	**208**	**2.57**	**17,397,209**	**20.44**

Table 2. *(continued)*

U.S. and Mexican Urban Area and Patches and Percentage by Subarea and Country[1]							
Urban Area		Mexico		U.S.		Total	
Subarea	Subarea Area km²	Area km²	%	Area km²	%	Area km²	%
Pacific Basins-Salton Trough	36,269.25	449.62	1.24	1,249.12	3.44	1,698.74	4.68
Colorado River-Sea of Cortez	8,599.81	116.89	0.20	55.11	0.26	272.00	0.46
Mexican Highlands	6,452.90	7.46	0.14	1,142.03	2.02	1,219.49	2.16
San Basilio-Mimbres	32,227.67	55.34	0.17	59.27	0.18	114.61	0.36
Rio Grande: Elephant Butte Reservoir to above Río Conchos	75,838.75	302.47	0.40	1,049.49	1.38	1,351.96	1.78
Rio Grande: Río Conchos to Amistad Reservoir	88,868.85	22.85	0.03	14.27	0.02	37.12	0.04
Rio Grande: Below Amistad Reservoir to Falcon Reservoir	3,475.08	71.45	0.81	289.42	0.86	560.87	1.68
Lower Rio Grande Valley	26,674.72	334.14	1.25	1,168.71	4.38	1,502.85	5.63
Total	**408,407.03**	**1,630.22**	**0.40**	**5,127.42**	**1.26**	**6,757.64**	**1.65**

[1] Urban area data from 2006 were obtained from the U.S. Census (California, Arizona, and New Mexico), the Texas Natural Resources Information System (TNRIS-Texas), and Mexico's INEGI. Subarea data were obtained from the USGS, U.S.-Mexican BEHI, and the INEGI. Land use and land cover classifications are derived from the USGS 2001 National Land Cover dataset in the U.S. and the INEGI Uso de Suelos y Vegetación Series III dataset in Mexico.

Table 2. *(continued)*

Urban Patches	Mexico		U.S.		Total	
Subarea	Number	%	Number	%	Number	%
Pacific Basins-Salton Trough	22	70.97	9	29.03	31	14.90
Colorado River-Sea of Cortez	14	63.64	8	36.36	22	10.58
Mexican Highlands	11	42.31	15	57.69	26	12.50
San Basilio-Mimbres	4	57.14	3	42.86	7	3.37
Rio Grande: Elephant Butte Reservoir to above Río Conchos	6	24.00	19	76.00	25	12.02
Rio Grande: Río Conchos to Amistad Reservoir	3	37.50	5	62.50	8	3.85
Rio Grande: Below Amistad Reservoir to Falcon Reservoir	14	66.67	7	33.33	21	10.10
Lower Rio Grande Valley	21	30.88	47	69.12	68	32.69
Total	**95**	**45.67**	**113**	**4.33**	**208**	

Source: Authors.

Natural Protected Areas

In many countries, the establishment of natural protected areas is one of the main strategies used in environmental management to protect ecosystems. Natural protected areas represent important sources of environmental services. However, a means to assess the value of ecosystem services does not exist, and this impairs the administration of the protected areas (FAO 2009).

Approximately 330 natural protected areas cover around 20% (83,492.56 m^2) of the border subareas. More than 79% of the natural protected areas are on the U.S. side of the border, and most of these lie in the western portion of the border. Thus, subareas like the Rio Grande: Below Amistad Reservoir to Falcon Reservoir have small areas of land protected. Only 14 of these protected areas exist in Mexico, but they are six times larger than the average protected areas of the U.S. Nonetheless, a large proportion of land in Mexico is not intensively used and managed; these lands exist under a regime of community land tenure that does provide some protection of ecosystem services.

In Mexico, most land in protected areas is not property of the federal government; these areas include mostly *ejidos* and community property where people are living and extracting a livelihood from resources of the area. In contrast, in the U.S., most of the protected areas are owned by the federal government or by state governments. Data documenting these variations in distribution and management are in Table 3.

Mexico's protected areas are all managed by its National Commission of Natural Protected Areas (Comisión Nacional de Áreas Naturales Protegidas–CONANP). In the U.S., several agencies are involved, mainly the Bureau of Land Management (58%), USDA Forest Service (16.5%), U.S. Fish and Wildlife Service (13%), and the National Park Service (9.7%). The balance of the protected areas in the U.S. is managed by the U.S. Department of Agriculture, U.S. Department of Defense, U.S. Army Corps of Engineers, Bureau of Reclamation, and the National Oceanic and Atmospheric Administration. Several state agencies are also involved with management of these areas.

Table 3. U.S. and Mexican Natural Protected Areas and Percentage by Subarea

Protected Area	Mexico		U.S.		Total	
Subarea	Area km^2	%	Area km^2	%	Area km^2	%
Pacific Basins-Salton Trough	29.72	0.08	10,603.19	29.23	10,632.91	29.32
The Colorado River-Sea of Cortez	9,730.37	16.60	16,542.44	28.23	26,272.81	44.83
Mexican Highlands	104.09	0.18	12,605.07	22.33	12,709.16	22.51
San Basilio-Mimbres	-	-	6,642.93	20.61	6,642.93	20.61
Rio Grande: Elephant Butte Reservoir to above Río Conchos	-	-	14,831.13	19.56	14,831.13	19.56
Rio Grande: Río Conchos to Amistad Reservoir	4,531.95	5.10	5,456.44	6.14	9,988.39	11.24
Rio Grande: Below Amistad Reservoir to Falcon Reservoir	16.43	0.05	25.81	0.08	42.24	0.13
Lower Rio Grande Valley	1,489.58	5.58	883.41	3.31	2,372.99	8.90
Total	**15,902.14**	**3.89**	**67,590.42**	**16.55**	**83,492.56**	**20.44**

Source: Authors.

The ecoregions best represented by protected areas within the study area are the Sonoran and Chihuahuan deserts. This is notable, as these ecosystems usually do not compete with human economic activities. The ecoregions least represented by protected areas are the Mojave Basin and Range, followed by the Southern Texas Plains/Interior Plains and Hills with Xerophytic Shrub and Oak Forest. Data documenting these variations in distribution are detailed in Table 4.

Basin Impact

The impact of urban land use and population pressures on various subbasins is reflected by the values of the pressure index that was introduced earlier in the paper. Population, the extent and patchiness of urban areas, and the extent of protected areas are aggregated in this index as well as values for the different subregions examined are presented in Table 5.

From the perspective of population distribution and the attendant demand for resources, the most impacted subarea is the Lower Rio Grande Valley. This region sees the most scattered distribution of urban areas, with very low densities (especially on the U.S. side of the border), reflecting the spatial pattern of agricultural activity. At the same time, this subarea has almost 9% of its area protected (with roughly equal portions in the U.S. and Mexico), but only in the Western Gulf Coastal Plain ecoregion, leaving the Southern Texas Plains/Interior Plains and Hills with Xerophytic Shrub and Oak Forest without protection.

The second most impacted subarea is the Pacific Basins Trough. This area is both the most populated and the region with the greatest extent of urban areas. The population is mainly scattered in Mexico but with much higher population densities than in the U.S., where lower population densities exist in much larger urban patches. Almost 30% of this subarea is protected, where California Coastal Sage, Chaparral and Oak Woodlands, and Sonoran Desert ecoregions are represented; virtually all of the protected area lies in the U.S.

The Rio Grande: Elephant Butte Reservoir to above Río Conchos subarea reflects moderate spatial impacts of human activity; 70% of the population is concentrated on the Mexican side of the border, scattered in a larger number of patches than in the U.S. These

Table 4. U.S. and Mexican Natural Protected Areas by Ecoregion (km²)

Subarea	Ecoregion	Mexico Protected Area	U.S. Protected Area	Total
Pacific Basins-Salton Trough	California Coastal Sage, Chaparral, and Oak Woodlands	29.81	2,674.96	2,704.77
	Mojave Basin and Range	0	268.11	268.11
	Sonoran Desert	18.24	7,641.78	7,660.02
Colorado River-Sea of Cortez	Sonoran Desert	9,660.59	16,555.86	26,216.45
Mexican Highlands	Sonoran Desert	0	1,328.51	1,328.51
	Madrean Archipelago	104.09	9,554.42	9,658.51
	Chihuahuan Desert	0	1,717.54	1,717.54
San Basilio-Mimbres	Chihuahuan Desert	0	6,006.30	6,006.30
	Madrean Archipelago	0	629.87	629.87
Rio Grande: Elephant Butte Reservoir to above Río Conchos	Arizona/New Mexico Mountains	0	3,217.38	3,217.38
	Southwestern Tablelands	0	432.34	432.34
	Chihuahuan Desert	0	11,173.72	11,173.72

Table 4. *(continued)*

Subarea	Ecoregion	Mexico Protected Area	U.S. Protected Area	Total
Rio Grande: Río Conchos to Amistad Reservoir Subarea	Chihuahuan Desert	4,533.27	5,295.30	9,828.57
	Southern Texas Plains/Interior Plains and Hills with Xerophytic Shrub and Oak Forest	18.01	169.63	187.64
Rio Grande: Below Amistad Reservoir to Falcon Reservoir	Chihuahuan Desert	0	1.06	1.06
	Southern Texas Plains/Interior Plains and Hills with Xerophytic Shrub and Oak Forest	0	24.74	24.74
Lower Rio Grande Valley	Southern Texas Plains/Interior Plains and Hills with Xerophytic Shrub and Oak Forest	521.41	60.96	582.37
	Western Gulf Coastal Plain	935.23	763.89	1,699.12
	Total	**15,820.65**	**67,516.37**	**83,337.02**

Source: Authors.

Table 5. Normalized Variables, Pressure Index, and Protected Area per Subarea and Country

Subarea	Country	Urban Area	Urban Patches	Population	Density	Pressure Index	Protected Area
Pacific Basins-Salton Trough	U.S.	0.79	0.19	0.95	0.12	1.81	1.00
	Mexico	0.28	0.47	0.74	0.26	1.23	0.00
	Total	**1.07**	**0.66**	**1.69**	**0.37**	**3.04**	**1.00**
Colorado River-Sea of Cortez	U.S.	0.06	0.17	1.00	1.00	0.23	0.97
	Mexico	0.05	0.30	0.33	0.44	0.24	0.57
	Total	**0.11**	**0.47**	**1.33**	**1.44**	**0.47**	**1.53**
Mexican Highlands Subarea	U.S.	0.46	0.32	0.42	0.06	1.14	0.76
	Mexico	0.03	0.23	0.10	0.20	0.17	0.01
	Total	**0.49**	**0.55**	**0.52**	**0.26**	**1.31**	**0.77**
San Basilio-Mimbres	U.S.	0.04	0.06	0.02	0.04	0.08	0.71
	Mexico	0.04	0.09	0.03	0.07	0.08	0.00
	Total	**0.08**	**0.15**	**0.04**	**0.12**	**0.15**	**0.71**
Rio Grande: Elephant Butte Reservoir to above Río Conchos	U.S.	0.32	0.40	0.30	0.04	0.98	0.67
	Mexico	0.09	0.13	0.41	0.21	0.42	0.00
	Total	**0.41**	**0.53**	**0.71**	**0.25**	**1.40**	**0.67**

Table 5. *(continued)*

Subarea	Country	Urban Area	Urban Patches	Population	Density	Pressure Index	Protected Area
Rio Grande: Río Conchos to Amistad Reservoir	U.S.	0.00	0.11	0.01	0.08	0.04	0.21
	Mexico	0.01	0.06	0.01	0.05	0.03	0.17
	Total	**0.01**	**0.17**	**0.01**	**0.13**	**0.07**	**0.38**
Rio Grande: Below Amistad Reservoir to Falcon Reservoir	U.S.	0.20	0.15	0.10	0.05	0.39	0.00
	Mexico	0.18	0.30	0.22	0.13	0.58	0.00
	Total	**0.38**	**0.45**	**0.32**	**0.18**	**0.97**	**0.00**
The Lower Rio Grande Valley	U.S.	1.00	1.00	0.34	0.05	2.30	0.11
	Mexico	0.29	0.45	0.38	0.18	0.94	0.19
	Total	**1.29**	**1.45**	**0.73**	**0.22**	**3.23**	**0.30**

Source: Authors.

patches cover roughly the same amount of land, but with much higher population densities. Almost 20% of the area is protected, representing the Arizona/New Mexico Mountains, Southwestern Tablelands, and the Chihuahuan Desert ecoregions. Again, virtually all of the protected area lies in the U.S.

Within the Mexican Highlands subarea, we also see a moderate overall spatial impact. This subregion in the U.S. has more population and urban area extent, yet also lower population densities than the subregion in Mexico. More than 22% of the area is protected, including the Sonoran Desert, the Madrean Archipelago, and the Chihuahuan Desert ecoregions. Most of the protected areas lie in the U.S., with a small contribution in Mexico.

The Rio Grande: Below Amistad Reservoir to Falcon Reservoir subarea experiences a moderate impact, with higher population and urban spatial extent, yielding lower population densities. Within this subarea only 0.13% of the area is protected, affording limited protection of the Southern Texas Plains/Interior Plains and Hills with Xerophytic Shrub and Oak Forest.

The Colorado River-Sea of Cortez has the second largest population of the border subareas, and limited patches of populated area yields the highest population densities. Although not considered in this index, the diversion of large volumes of water from the Colorado River in this subarea to other regions generates a very large impact to ecosystem services. Due to large-scale impoundments in the dams on the main stem, flows within the river are highly regulated and manipulated and lack any natural flood dynamic. Flora and fauna that historically relied on this flood dynamic are hence greatly impacted. Within this subregion, the Sonoran Desert ecoregion is the most protected subarea in the border, with almost 45% of its area set aside under different categories of protection on both sides of the border.

The San Basilio-Mimbres Subarea has small amounts of urban area and smaller urban patches. This spatial configuration couples with the lowest population numbers and moderate population densities to generate limited spatial impacts. The Chihuahuan Desert ecoregion is well represented in this region, with more than 20% of its area being protected, mostly in the U.S.

The least impacted subarea of those explored is the Rio Grande: Río Conchos to Amistad Reservoir, a subregion with the lowest population and least extensive urban areas on both sides of the border. More than 11% of its area is entirely contained within the Chihuahuan Desert ecoregion that is protected with approximately equal contributions from each country.

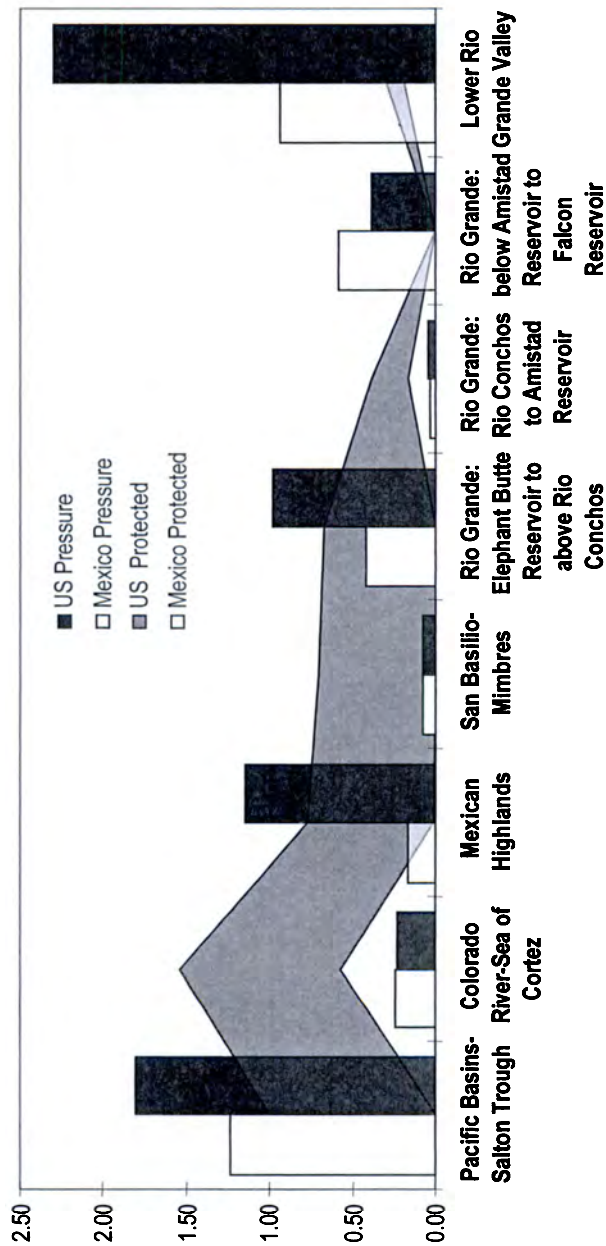
Figure 3 provides a graphic representation of the values contained in Table 5 and discussed in the previous text. We see considerable variation between the amount of land in protection and pressure on unprotected lands that result from urban areas with different levels of population.

Perspectives and Public Policies

Discussion of Population Projections

As noted in Table 6, population levels in most of the subregions being examined are projected to increase between 47% and 114% in the 30-year period from 2000 to 2030 (see footnote in table for reference to projections). The San Basilio Mimbres and the Rio Grande: Río Conchos to Amistad Reservoir subareas are notable exceptions to this trend, with population growth rates that are basically flat for this period of time. What are the likely impacts of this popution growth on ecosystem services? It is likely that current patterns of urbanization will continue in this time period, and this will most likely cause the trends in the values of the pressure index documented previously to continue. Larger expanses of land will experience urbanization, larger amounts of surface and groundwater resources will be demanded by urban populations, and existing natural and protected areas will see increasing pressure, both to convert these areas to other land uses and from larger numbers of people visiting these areas. Given these expected pressures on ecosystem services, discussion now turns to the manner by which resources are managed in the border region and policy options that may be crafted to deal with these pressures.

Figure 3. Urban and Population Pressure Index and Protected Areas per Subarea and Country



Source: Authors.

Table 6. Population Projections per Subarea and Country[1]

Subarea	Country	Density 2006	Population 2000	Population 2005	Population 2010	Population 2020	Population 2030
Pacific Basins-Salton Trough	U.S.	2.47	2,956,194	3,084,974	3,389,381	3,789,863	4,234,450
	Mexico	5.36	1,948,581	2,409,938	2,786,448	3,581,234	4,403,324
	Total	**3.23**	**4,904,775**	**5,494,912**	**6,175,829**	**7,371,097**	**8,637,774**
Colorado River-Sea of Cortez	U.S.	20.95	2,875,282	3,249,938	3,679,436	4,389,280	5,029,284
	Mexico	9.15	907,147	1,069,785	1,180,296	1,391,862	1,587,282
	Total	**15.88**	**3,782,429**	**4,319,723**	**4,859,732**	**5,781,142**	**6,616,566**
Mexican Highlands	U.S.	1.19	1,185,541	1,356,120	1,637,857	2,120,068	2,561,380
	Mexico	4.19	279,823	324,869	355,925	404,840	439,712
	Total	**1.38**	**1,465,364**	**1,680,989**	**1,993,782**	**2,524,908**	**3,001,092**
San Basilio-Mimbres	U.S.	0.93	56,018	55,274	61,611	69,223	75,600
	Mexico	1.56	85,749	86,469	83,325	75,674	67,400
	Total	**1.24**	**141,767**	**141,743**	**144,936**	**144,897**	**143,000**
Rio Grande: Elephant Butte Reservoir to above Río Conchos	U.S.	0.94	938,398	983,035	1,078,327	1,202,322	1,367,847
	Mexico	4.39	1,163,090	1,328,343	1,447,483	1,652,805	1,815,053
	Total	**1.71**	**2,101,488**	**2,311,378**	**2,525,810**	**2,855,127**	**3,182,900**

Table 6. *(continued)*

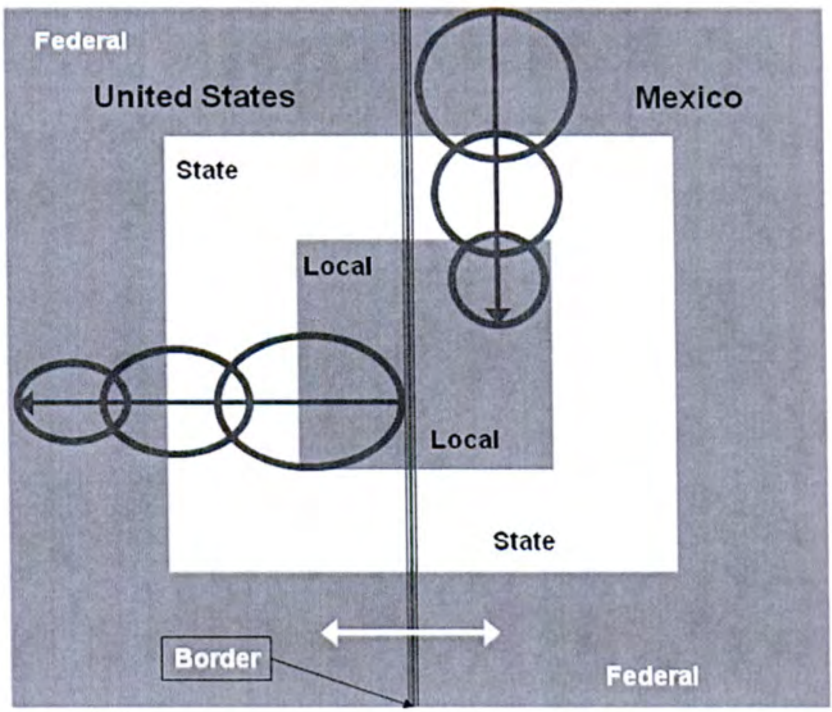
Subarea	Country	Density 2006	Population 2000	Population 2005	Population 2010	Population 2020	Population 2030
Rio Grande: Río Conchos to Amistad Reservoir	U.S.	1.61	24,290	22,928	25,597	25,943	27,059
	Mexico	1.10	27,497	25,054	22,254	18,025	14,951
	Total	1.29	51,787	47,982	47,851	43,968	42,010
Rio Grande: Below Amistad Reservoir to Falcon Reservoir	U.S.	1.11	288,649	321,549	366,327	436,224	519,521
	Mexico	2.66	633,995	721,432	782,797	889,180	973,321
	Total	**1.86**	**922,644**	**1,042,981**	**1,149,124**	**1,325,404**	**1,492,842**
Lower Rio Grande Valley	U.S.	0.96	978,369	1,118,392	1,299,958	1,641,290	1,756,525
	Mexico	3.71	1,078,494	1,239,109	1,363,297	1,588,152	1,773,110
	Total	**1.57**	**2,056,863**	**2,357,501**	**2,663,255**	**3,229,442**	**3,529,635**
	Grand Total	**2.57**	**15,427,117**	**17,397,209**	**19,560,318**	**23,275,985**	**26,645,819**

[1] INEGI, XII Censo General de Población y Vivienda 2000; U.S. Census Bureau, Census of Population and Housing 2000. CONAPO, Proyecciones de Población de México 2005–2030; State of California, Department of Finance, Population Projections for California and Its Counties 2000–2050, Sacramento, California, July 2007; Arizona Department of Commerce, The Center for Economic Advancement, Arizona Projections 2006–2055; Bureau of Business and Economic Research, University of New Mexico, New Mexico County Population Projections July 1, 2005, to July 1, 2035, Released August 2008; Texas State Data Center, The University of Texas at San Antonio, Texas Population Projections 2000–2040.
Source: Authors.

Comparative Analysis of Land-Use Administration on the Border

In order to preserve ecosystem services, land-use administration must be taken into account. Land-use administration is confined to the geographical space defined by jurisdictional limits, whereas the consequences of actions are distributed according to the spatial pattern of human activities and resulting impacts (Platt 1996). The manner by which resource management decisions are rendered and implemented also varies greatly between the U.S. and Mexican portions of the border. Figure 4 details a conceptual model of the manner by which land-use management unfolds within the different legal frameworks in the U.S. and Mexico.

Figure 4. Conceptual Model of Land-Use Management within Legal Frameworks on the U.S.-Mexican Border



Source: Authors.

In the U.S, according to Amendment 10 of the U.S. Constitution and the court case, *Merriam v. Moody's Executors,* state governments and, by extension, local governments have the power to legislate and to manage urban land uses. Accordingly, each area develops its own strategy without general plans. The role of the federal government is indirect. This role includes the funding of infrastructure and fiscal incentives, promoting housing development (Federal Housing Administration), granting certain tax advantages, investing in highway infrastructure (Federal Highway Act), and establishing federal environmental standards (Clean Air Act and Clean Water Act) (Peña and Fuentes 2005).

In Mexico, actions not explicitly assigned to the federal government are granted to the states (Article [Art.] 24 of the Constitution), but the federal Congress has the power to legislate planning (Art. 73, Section [Sect.] XXXIX-C). With this land-use planning authority existing within Congress, the General Law of Human Settlements (Ley General de Asentamientos Humanos–LGAH) was approved in 1976. In the 1983 reform of the LGAH, more responsibilities were granted to the municipalities to regulate land uses (Art. 115, Sect. V) (Peña and Fuentes 2005). In 1988, the General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente–LGEEPA) was approved as an instrument of environmental policy. This law also addressed land-use planning and, in a 1996 reform, the ability to carry out land-use plans was given to the municipalities. With this reform, "The separation between two types of land uses (the urban and the rural) was consolidated, under the assumption that they can be separated as a response to social organizations' demands" (Azuela 2006).

Although the concept of land-use planning is similar in the two countries, the interpretation and application of planning differs. According to Azuela and Dahau (1993), in the U.S., planning has followed a legalistic-incremental model where the judicial system clarifies property rights by legal cases, defining in each case if an action is in the public interest. In contrast, in Mexico, planning follows a client-optional approach, where the social and political context and the interests of the ruling party define planning.

As for the coordination of the different government levels, in the U.S., the federal government has limited planning power. There are no national urban laws, so coordination must be realized under specific programs or by state or local governments. Conversely, in Mexico, the federal government has coordinating power among three levels of government (Arts. 26 and 73, Sect. XXXIX-C). Examples are the Watershed Councils that are coordinated by the National Water Commission (Comisión Nacional del Agua–CONAGUA), with the intent being the management of hydrologic resources within a regional framework (Peña and Fuentes 2005).

Although communities in the U.S. play an important role in land-use planning, the municipalities in Mexico have had a very weak role. In the U.S., land use is usually negotiated between market and community values. Local officials are chosen by districts, they can be reelected, and citizens can push a member out if the member goes against the interests of the citizens. In Mexico, the LGAH dictates standards according to one approach for all. The members of a council or *cabildo* are chosen according to membership in the local party slate, and actions of the council reflect proportional representation of the political parties involved, not the needs or interests of the local residents (Peña and Fuentes 2005).

In the U.S., land-use planning has been basically a local process, without state coordination, focused on individual topics (air contamination, transport, and others) and ignoring the risk of multiple threats (Turner and Rylander 2000). At the state level, policies have focused on areas of rapid urban growth, but policies have changed to be more focused on environmental issues. This change of focus occurred in the 1960s and 1970s, reflecting the idea of smart growth as a reaction to the increase of social and environmental costs caused by the dispersed expansion of the suburbs. Although federal participation and interest in regional planning have increased, it is still small, due to the absence of general land-use policies and an old tradition of local control (Bengsten et al. 2004).

Some shortcomings of urban planning in Mexico are that planning efforts do not construct future scenarios and that they lack social participation processes. Additional shortcomings include the absence of instruments to link land-use markets and regulation, the lack of statistical and geographical information, the absence of mechanisms to evaluate outcomes, the lack of financial sources, and the weak articulation of land-use management programs (Alegría, Olazábal, and Ordóñez 2005).

As Bengsten et al. (2004) state, shortcomings in the U.S. include the failure to evaluate public policies and their impacts, little consideration of the implementation phase and of administrative efficiency, weak vertical and horizontal coordination, and the scarce participation of actors that are involved.

Although plans in each country try to be comprehensive, they both end at the border. This is due, partly, to the fact that legally, the border communities cannot carry out binational agreements, because this power is reserved for the federal government in both countries (Art. 89, Sect. X, Mexican Constitution and Art. 1, Sect. 10 and Amendment 10, U.S. Constitution). Planning in the border region has historically concentrated on topics of international limits and binational waters through the work of the International Boundary and Water Commission, both the U.S. and Mexican sections. While there have been coordinated initiatives (Border XXI and Border 2012 environmental management programs and the long-standing Border Governors Conference), these have not included active efforts toward binational land-use planning (Peña and Fuentes 2005). Mumme and Brown (2002) indicate that the planning on the border has changed from a central model with the federal government in control toward one of administrative decentralization. The federal government, in essence, downloads administrative functions of planning to state and local governmental units, but it also exerts a limited level of control through regulations and financial connections.

The Case of the Colorado River Basin

With the previous discussion of the analysis of impacts on environmental services and the policy framework that exists in the border region in place, we now examine the Colorado River Basin as a case study to examine how these various elements come together in a binational watershed context. As stated in the Colorado River Compact of 1922, the Upper Basin includes the areas of the watershed within the states of Colorado, New Mexico, Utah, and Wyoming, and the Lower

Basin encompasses Arizona, California, and Nevada. Furthermore, each basin is afforded an initial allocation of 7.5 million acre-feet with which to meet its needs.

The Colorado River irrigates 3.5 million acres of farmland and supports 30 million people in the U.S. and Mexico. The water in this binational watershed is directly consumed or supplied for livestock, industrial, mining, and thermoelectric uses, and irrigates more than 2.7 million acres of farmland in the Lower Basin. Water diverted for human uses comes at the expense of water that is also necessary for ecosystem services. Degradation of these ecosystem services affects the production capacity and biodiversity of aquatic, riparian, wetland, and estuarine areas. These areas provide habitat; breeding and feeding areas for terrestrial, aquatic, and marine species, and migratory birds; and commercial and sport fisheries. In addition, these areas also contribute to sustained surface flow and flood control, groundwater recharge, and removal of pollutants through soil filtration. This latter process also increases the resilience of ecosystems to cope with changing conditions. Related biological processes help to regulate the flow of water and sediment; such regulation is the outcome of complex interactions among climate, precipitation, topography, vegetation, and human alterations (Lellouch et al. 2007).

The Colorado River Basin's engineered system has brought benefits to people, but it cannot replace the complex interactions of ecosystems. The change in the flow regime resulting from the engineering of the basin has endangered native species, increased nonnative species, and reduced the river delta to less than 10% of its original size (Luecke et al. 1999). Recurring droughts bring greater variability and uncertainty to the hydrologic cycle. Thus, vulnerability can increase as population and water demand grow and choices become fewer and more difficult to make. In the last seven years, the Lower Basin had one of the worst droughts in history, with a 50% loss in storage (Lellouch et al. 2007).

Population growth and climate change have the greatest impact on water in the basin. Between 2000 and 2030, the Lower Basin states' population is projected to grow by an additional 11 million people (U.S. Census 2005b), with an increased areal extent of housing and urban development (Markham 2006). This will place greater pressure on urban water supplies, hasten the shift from agricultural to urban land uses, and generate increased pressure on natural and protected areas and related ecosystem services.

Global warming is expected to generate a 1 to 2°C increase in ambient temperatures in the next 50 years (Barnett et al. 2004). This will raise evaporation rates, reduce the extent and mass of regional snowpack, decrease water sources, and alter the temporal and spatial patterns of annual runoff (Stewart et al. 2004). Stronger El Niño and La Niña conditions will increase the intensity of precipitation events and drought (Merideth 2001), and drought cycles will lengthen and deepen (Hoerling and Eischeid 2007). Models project decreased surface water flows ranging from 11% by 2100 (Christensen and Lettenmaier 2006) to 45% by 2050 (Hoerling and Eischeid 2007).

Environmental services have not been adequately accounted for in the management of regional water resources in the basin. The benefits of water diversion have been determined to be of greater value to society than those of healthy ecosystems and the negative consequences tend to fall on marginalized stakeholders who have little bargaining power. Negative impacts on ecosystem services will not be considered unless changes in their condition have economic consequences for humans. Valuation of ecosystem services requires a process of negotiation that identifies policy goals and trade-offs between ecosystem services and the consumptive use of water resources. Although ecosystem values change, allocation of the water budget reflects values that existed at the time that policy decisions determined who had access to benefits. Negotiation of the Colorado River Water Compact and related laws and agreements were based on the Doctrine of Prior Appropriation, which enabled the faster growing state of California to appropriate a larger share of water than other states. Recent actions on the part of the U.S. Department of the Interior to ensure that Upper Basin states obtain their share of water under the Colorado River Water Compact have yielded changing conditions that have made trade-offs between ecosystem services and economic development more evident (Lellouch et al. 2007).

Any allocation of water to the river reduces vulnerability to future reduction in flows, as it provides a buffer against variability. However, because of incentives in the existing structure, water is usually consumed for municipal and industrial uses instead of supporting vegetation with lower water requirements. If newly devised rules were to allow credits to be received for water conserved, such conserved water could be stored instream where it can provide social benefits (Lellouch et al. 2007).

Values can be inferred from policy objectives and willingness to pay. Willingness to pay the costs of water conservation will depend on levels of benefits relative to the cost, whether payment received is accepted as fair, and whether sufficient confidence exists in the efficiency of conservation measures. Rivera and Carrillo Guerrero (2006) quantified the stakeholders' willingness to pay for enhanced river flows. Although values obtained were much lower than those of agriculture, the existence of these values demonstrate growing recognition of the value of ecosystem protection and services.

The importance of protecting the Colorado River Delta is being recognized by policymakers in both countries and the International Boundary and Water Commission, as IBWC Minute 306 implicitly recognizes the importance of protecting the delta. The cooperation among the basin states and Mexico may allow the capture of water above current demands, allowing the storage of water during surplus years for use in drought years. Such a regime of generating increased storage could also be extended for restoration of the delta. Restoration will bring ecological, economic, and social benefits, such as increased riparian and marsh wetlands for migratory and resident birds; revenues from tourism, hunting, and fishing; social cohesion; and recreational opportunities (Zamora-Arroyo and Lellouch 2007).

Discussion and Conclusions

In this paper, we have introduced the concept of ecosystem services and also discussed a range of these services that are related to the regional ecosystems that exist in the U.S.-Mexican border region. We then laid out a method for evaluating these services through the development of a pressure index that reflects population levels, urban extent, population densities, and area extent of protected areas. Through the application of this index, we measured the pressure that urbanization, land fragmentation, and population growth is exerting on the critical ecosystems indentified in this paper. With this quantitative analysis in place, we then explored the institutional landscape that guides land

and water resource planning and identified some of the shortcomings in this planning regime. The case of the Colorado River Watershed was then examined with an eye toward integrating the overall concept of ecosystem services, the quantitative analysis conducted, and the discussion of the institutional context on the border.

Ecosystem services provide current and long-term value to both the environment and to humans that depend on the environment to meet economic and other needs. To help protect these services for current and future residents of the border region, land and water resource use decisions must be made within a longer time frame in which a broader set of societal needs are examined. The binational nature of the U.S.-Mexican border region poses certain challenges to making these decisions, yet potential exists for a more holistic perspective to be advanced as discussed below.

Border XXI and Border 2012, the binational environmental management frameworks that the U.S. and Mexico have developed and implemented in the last 20 years, offer useful mechanisms for regional cooperation that can help protect environmental services. Domestic watershed councils have been developed in Mexico under the National Water Law that offer utility for exploring a wider range of uses of water resources and resulting benefits, and previous research has explored the degree to which such councils could take on a binational nature (Brown and Mumme 2000; Brown 2005). Current discussions between one of the authors and the leadership of the U.S. and Mexican sections of the IBWC are exploring alternate means of advancing binational water management that could lead to the protection of ecosystem services on the border (Brown et al. 2008).

The Border Liaison Mechanism (BLM) is a formal binational vehicle for cooperation that enjoys representation of the U.S. and Mexican federal governments and foreign ministries at the highest level through the membership of the consuls general. The BLM was established in 1993 though diplomatic notes exchanged by the U.S. Department of State and its Mexican counterpart, the Ministry of Foreign Affairs (Secretaría de Relaciones Exteriores–SRE). Through the participation of the local U.S. and Mexican consuls general, the BLM provides a multilevel consultative mechanism on issues of regional importance with several councils that focus on specific topical issues (e.g., ports of entry, public safety, and automobile thefts). As such, the BLM offers a useful tool by which water and land resource management decisions can be advanced that help to protect ecosystem services with local input and concurrence from U.S. and Mexican federal agencies that may control or guide funding. In fact, the BLM tool was used in the San Diego-Tijuana region in the late 1990s to advance a binational and regional discussion on shared water resource management in the Tijuana River Watershed that is consistent with protecting ecosystem services via a watershed approach.

The authors offer this paper as a foundation on which this important work can be advanced, yet more work is needed in the area of ecosystem services, both in refining tools by which the value of these services can be measured and in exploring institutional and policy mechanisms to better protect them. A specific area worthy of future research is into the capacity of utilizing geospatial tools to link landscape ecology ideas with those of ecosystem services. Through the overlay of geospatial data layers of species richness and diversity in areas of critical environmental concern, with the extent of urban areas in a geographic information systems (GIS) framework, the spatial co-occurrence of these variables can be explored in greater detail. The Fragstats GIS tool developed by McGarigal and Marks (1995) is a natural tool for future exploration of datasets including the National Land Cover Dataset, the Southwest Regional Gap Analysis Project, and Mexico's National Inventory of Forests and Soils (Inventario Nacional Forestal y de Suelos), and we suggest just such a research approach for future work with considerable potential in advancing the work begun in this publication.

Endnotes

[1] Data employed are from the U.S.-Mexican Border Environmental Health Initiative (BEHI), available at: http://borderhealth.cr.usgs.gov/datalayers.html.

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VII

Water Perspective in the Western U.S.-Mexican Border: Future Conflict?

O. Alberto Pombo and Richard D. Wright

Abstract

The future of the California-Baja California region depends on finding alternative sources of potable water and new ways of distributing existing water sources. Insufficient water supply will limit regional capacity to sustain long-term development and growth. The Colorado River is the most important water source for seven western U.S. states (Wyoming, Colorado, Utah, New Mexico, Nevada, Arizona, California) and Baja California in Mexico. Due to global climate change, it is predicted that a reduction in the availability of water from the Colorado River will force all users to renegotiate existing compacts and international treaties (CDWR n.d.).

Given the availability of surface and groundwater from traditional sources, it is clear that the population of Baja California is near carrying capacity. This means that if the population continues to grow, water currently being used to support agricultural production will have to be shifted to urban use. Any reduction in flow from the Colorado River may have catastrophic consequences for Baja California's development. The state is more vulnerable to the effects of a reduction in the volume of water delivered by the Colorado River. Unlike the U.S. states, Baja California lacks alternative sources, such as rivers or aquifers not related to the Colorado River, from which it can draw in the event of an emergency shortage.

The dilemma of diminishing water supply has the potential to create international conflicts that will test the capacity of leaders on both sides of the border. The position of Baja California in the event of a reduction of flow from the Colorado River is desperate and actions born in desperation may lead to conflict. The 1944 Water Treaty should be revamped to deal with this potentially explosive scenario. Both the federal governments of the U.S. and of Mexico will have to deal with this problem within the framework of the 1944 Water Treaty at a diplomatic level, but local actions will be fundamental in finding new, creative ways to cooperate in solving the common problem for the future of the region.

Introduction

Cities in Baja California have been growing during the past 30 or 40 years and they are predicted to continue growing rapidly in the near future (CEA 2008; CDWR n.d.). Population centers along the Pacific Coast (Tijuana, Rosarito, Ensenada) are the fastest growing cities in the state. Although they use some water from local sources (Ensenada and parts of Tijuana), the bulk of the water consumed (87.3%) comes from the Colorado River, which is conveyed to the coastal region by an aqueduct that is at capacity. According to Mexico's National Water Commission (Comisión Nacional del Agua–CONAGUA), most local aquifers are overexploited or near capacity for extraction and these account for 35% of all water sources in the state (CEA 2008).

Global climate change has the potential to alter the current allocation of Colorado River water to Mexico and affect the flow of the river; thus, the U.S. is likely to make sure it can meet its own needs first in the event of a shortage. Due to the heavy dependence on this source by Baja California, there is the potential for binational conflict between the U.S. and Mexico that will have to be resolved under the framework of the 1944 Water Treaty (Mumme 2003). The U.S. Farm Bureau has also seized on the effects of climate change to argue for additional surface water storage. Climatologists predict that more rain than snow will fall in California and existing reservoirs that are designed to capture a gradual snow melt will not be able to accommodate the resulting flood-like conditions (Grenoble 2010).

POPULATION GROWTH VERSUS CARRYING CAPACITY

The population of Baja California is mostly concentrated in the urban areas of the municipalities of Mexicali, Tecate, Tijuana, Rosarito, and Ensenada, accounting for nearly 82% of the state's population. The growth rate has been declining over the years, but it is still one of the highest in Mexico. During the 2000–2005 period, the average annual growth rate in the state was a historic low of 2.7%, with a population in 2005 of 2,844,469 inhabitants; yet, if this trend continues, the population will double by the year 2030 to more than 5.5 million inhabitants (INEGI 2007).

Most of the population of Baja California is located in the Pacific Coast region, far from the largest river of the state, the Colorado River. Baja California is a migratory magnet; only 47.8% of the population living in the state in 2005 was born in Baja California. Over 42% of the residents came from Sinaloa, Jalisco, Sonora, and other states. Approximately 11% of the population is from another country or origin not specified (INEGI 2007). The proximity of Baja California to California—as well as its level of economic development—has attracted large numbers of migrants in search of a better quality of life and economic opportunity. Most migratory flows from the state's municipalities are directed toward the city of Tijuana.

The annual growth rate in new home construction increased to 7.8% during the 1990–2000 decade, up from 4.4% in the 1980–1990 decade, and placing the state in second place at the national level. A larger number of homes meant a reduction of the average number of occupants per dwelling, in spite of an increase in population. This is an indication of a general improvement in the quality of life. In a similar manner, the total water demand for human consumption is also increasing. An individual living in informal periurban settlements without public services in Baja California uses about 50 liters of water per day, but if the individual relocates into the city, that person's water consumption typically increases to about 150 liters per day (Pombo 2003).

Based on data from CONAGUA, the volume of water available in Baja California per year is 3,622 million cubic meters (Mm^3). Sources include 672 Mm^3 from rain and snow runoff, 1,850 Mm^3 from the Colorado River, and 1,100 Mm^3 from aquifers. The annual demand for water in the state is 3,336 Mm^3, comprised of 1,869 Mm^3 from surface runoff and 1,467 Mm^3 from aquifers. The available volume of surface water is 653 Mm^3, and there is a deficit of 367 Mm^3 from aquifers. Therefore, the volume available in theory would be the difference between the supply and demand, which is 286 Mm^3 (CEA 2008).

About 84% of the water budget in Baja California is dedicated to agricultural uses, 8.2% to urban uses, and a similar percentage to industrial applications (CEA 2008). Baja California is located in the northwest of Mexico, within the barren and semiarid zone of the country. With the exception of the Colorado River Delta, most aquifers in Baja California are characterized by small storage capacity and discharge into the sea. In addition, most are overextended to meet agricultural irrigation demand and the water needs of local communities.

CONAGUA recognizes 48 aquifers in Baja California with a total annual recharge of 1,099.50 Mm^3 and an extraction of 1,149.80 Mm^3. This number includes the aquifer of Mesa Arenosa in San Luis Río Colorado (Sonora) that is shared with Baja California. Its recharge rate is 100 Mm^3 and extraction rate is 197.30 Mm^3. The balance results in a total deficit of 50.03 Mm^3, but without the Mesa Arenosa contribution, the deficit would be on the order of 247.33 Mm^3 for Baja California (CEA 2008).

Colorado River Water Policies

The Colorado River Delta and the flow of its water to Mexico are tightly controlled. The 1944 U.S.-Mexico Treaty on the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande (1944 Treaty) commits the U.S. to deliver 196,100 m^3 of Colorado River water to Mexico each year. Of this volume, at least 177,868 m^3 are to be delivered at the Northerly International Boundary (NIB) and the remainder may be delivered at the Southerly International Boundary (SIB) near the mainstem.[1] In years in which a water surplus exists in excess of U.S. demands, the Treaty commits the U.S. to deliver up to an additional 26,076 m^3 of water to Mexico (Hundley 1966).

A 1973 amendment to the 1944 Treaty—and the resultant federal implementing legislation of 1977—led to the discharge of brackish (>2900 ppm) groundwater (previously discharged into the mainstem) into an area in the southeastern edge of the Colorado Delta. This brackish water greatly expanded the extent of the Ciénega de Santa Clara from some 200 hectares to an estimated 20,000 hectares (Glenn et al. 1992; Zengel et al. 1995; Cohen et al. 2001).

From its headwaters high in the Wind River Mountains of Wyoming, the Colorado meanders 1,400 miles and is the sole dependable water supply for 244,000 square miles, an area embracing parts of seven western U.S. states (Wyoming, Colorado, Utah, New Mexico, Nevada, Arizona, and California) and Baja California in Mexico. Though the watershed is vast, the Colorado is not a heavy flowing stream, ranking about sixth among U.S. rivers and having an average annual volume of less than 15 million acre-feet. This is only about 3% of the flow of the Mississippi and about 8% of that of the Columbia, but during the 20th century, this modest flow became the most disputed body of water in the U.S. and probably in the world. The controversies extend far beyond the basin and involve hundreds of miles of aqueducts that were built, or are being built, to support population centers and to develop the farms, cities, and industries of eastern Colorado, western Utah, central New Mexico, and, especially, the vast megalopolis of Southern California, stretching from north of Los Angeles to the Mexican border. Over the years, heavy reliance on the Colorado River has resulted in significant alteration to the appearance and quality of the Colorado's flow. Such heavy competition led to the creation of domestic and international agreements that sometimes harmonized and just as often exacerbated tense relations among water users, creating a legacy of laws, court decisions, and water-use patterns that continue to influence the lives of millions of people in the United States and Mexico (Hundley 1996).

California and the Colorado River

Population growth is a major factor influencing current and future water uses. From 1990 to 2005, California's population increased from about 30 million to about 36.5 million. The California Department of Finance projects that this trend means a state population of roughly 60 million by 2050.

California is one of the most productive agricultural regions in the world. Agriculture is an important element of California's economy, with 88,000 farms and ranches generating $32 billion in gross income in 2006 and generating $100 billion in related economic activity, according to the California Department of Food and Agriculture. In 2000, California irrigated an estimated 9.6 million acres of cropland using roughly 34 million acre-feet of applied water.

Prior to 2003, California's annual use of Colorado River water ranged from 4.5 million to 5.2 million acre-feet. Since then, Arizona began full use of its basic apportionment, and Nevada approached full use of its entitlement and surplus allocation. Therefore, California has had to reduce its dependence on Colorado River water to 4.4 million acre-feet in normal years (CDWR n.d.). The Colorado River Basin is experiencing a record drought that began about 2000, which has reduced reservoir storage throughout the river system to just over 50% of total storage capacity (CDWR n.d).

In an average water year like 2005, California receives close to 200 million acre-feet of water from precipitation and imports the remainder from streams that flow from Colorado, Oregon, and Mexico. Of this total supply, about 50–60% is either used by native vegetation, evaporates into the atmosphere, is used by agricultural crops and managed wetlands (referred to as effective precipitation), or flows to Oregon, Nevada, the Pacific Ocean, and saline sinks such as aquifers and the Salton Sea. The remaining 40–50%, identified as dedicated or developed water supplies, is distributed among urban and agricultural uses, for protecting and restoring the environment, or as storage in surface and groundwater reservoirs for later use. In any year, some of the dedicated supply includes water that is used multiple times (reuse) and water stored during previous years. Ultimately, about one-third of the dedicated supply flows to the Pacific Ocean or to salt sinks, in part to meet environmental water requirements for designated Wild and Scenic Rivers and other environmental needs and objectives.

California is facing one of the most severe water crises in its history—one that is hitting hard because it has so many aspects. Growing population and reduced water supplies are worsening the effects of a multiyear drought. Climate variation is reducing the snowpack storage and increasing floods. Court decisions and new regulations have reduced Bay Delta water deliveries by 30%. Key fish species continue to decline. In some areas of the state, the ecosystems and quality of underground and surface waters are unhealthy. The current global financial crisis will make it even more difficult to invest in solutions.

The challenge to make sure that stored water is readily accessible is at its greatest during dry years because if there is an insufficient supply of water available for agriculture (due to drought conditions for that year), it will lead to a greater reliance on groundwater sources, which in most cases are already overextended and will increase the cost to consumers. In the meantime, those who have already pared down their water use may find it more challenging to achieve additional water-use reductions.

The quality of California water is of particular and growing concern. Various water management actions can potentially have a negative effect on water quality. These include transfers, water recycling methods, conjunctive use of aquifers, storage and conveyance, Bay Delta operations, crop idling, and hydroelectric power. Degraded water quality can limit, or make very expensive, some water supply uses or options because the water must be pretreated. Furthermore, water managers increasingly recognize that the quality of various water supplies needs to be matched with intended use of the particular supply.

Climate variations may worsen the state's flood risk by producing higher peak flows and a shift toward more intense winter precipitation. Rising snowlines caused by climate change will cause the Sierra Nevada watersheds to contribute more to peak storm runoff. High-frequency flood events (e.g., 10-year floods) in particular may increase with a changing climate. Along with changes in the amount of the snowpack and accelerated snowmelt, scientists predict greater storm intensity, resulting in more direct runoff and flooding, which is exacerbated in urban areas by impervious land surfaces such as asphalt and concrete. Changes in watershed vegetation and soil moisture conditions will likewise alter runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, modifying channel shapes and depths, possibly increasing sedimentation behind dams and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is, in turn, a potential for more floods following fires, which increases sediment loads and affects water quality.

BAJA CALIFORNIA AND THE COLORADO RIVER

There are indications that Baja California is already developing strategies to cope with a reduction of the volume of Colorado River water delivered from the U.S. (Minor 2009). The high dependency on flows from the Colorado River, combined with its relatively low position on the totem pole of the Colorado River users, puts Baja California in a vulnerable position. California may be able to substitute Colorado River water with other sources—although with potentially significant impact on the environment—but that is not the case for Baja California since all alternative water sources are at capacity or overexploited.

The difficulty of meeting increasing water demand for Baja California is in large part due to the lack of new infrastructure as well as the development of new water sources. However, the principal limitation, at least for the short term, is the inelastic supply. For years, all policies were directed toward expanding the supply with more infrastructure, but the state's residents are at a crossroads where they are using almost all available water. In the short term, it means that they can no longer follow the models of development they have been using thus far. In the long run, new ways must be found for allocating the resources to the different users. In the near future, the only way to solve the hydraulic deficit of Baja California is to make more efficient use of the water in the state's economic and domestic activities.

Urban water scarcity has a different meaning on each side of the border. While San Diego County residential users consume an average of 685.2 liters per capita per day (181 gallons) Tijuana residential users consume 150 liters per capita per day (39.6 gallons) (*San Diego Union-Tribune* 2009; CEA 2008; Pombo 2003). In other words, a family of four in Tijuana consumes about the same quantity of water as a single individual in San Diego. Therefore, the potential impact of water-saving measures is different on each side of the border, with a far smaller margin of return for Baja California.

Due to its high importance in the water budget, water savings in agriculture is the only option that will provide the volume that is required to meet the needs of the increasing urban population. Although the indicators of irrigation efficiency in Baja California are the highest in Mexico, these indicators must be improved. Steps are already being taken in this regard and include the rehabilitation of the irrigation district of the Valley of Mexicali as well as the use of water saving technologies and low-water demand crops.

Confronting the Challenge

Wastewater reuse will eventually become a new source of water for the region. Presently, in Tijuana, recycled water is substituted for potable water in landscape maintenance and industrial sector applications. Also, the large volume of wastewater not adequately treated by public utilities is creating a pollution problem in the region when it could be put to a good use if properly treated. As an example, in California, the Orange County Water District runs the Water Factory 21 that is currently injecting 56,780 m3 (15 million gallons) per day of a blend of reclaimed and deep-well water into the Santa Ana aquifer to maintain the hydrostatic pressure of seawater intrusion barriers (Mills et al. 1998). The recycled water from Water Factory 21 meets drinking water standards through treatment using advanced processes. Recycled water was chosen for many reasons. Cost was a definite consideration, but even more important were the environmental advantages:

- Reduction of 18,500,000 m^3 (15,000 acre-feet) of wastewater discharged to the ocean annually
- Reduction of dependency on the State Water Project and Colorado River supplies
- Constant availability of reclaimed water supply; seawater intrusion barriers are the last priority when imported supplies are diminished by drought or emergency interruption of importation systems (Mills et al. 1998; OCWD 2007; Pombo et al. 2008)

Unfortunately, on a larger scale, such technological and infrastructural advancements are still a long way from being implemented to meet regional demand. And so, in the short term, the growing competition for Colorado River water—due to a growing population on both sides of the border—is setting the stage for a conflict that will have to be resolved within the legal framework of the 1944 Water Treaty. When this time comes, the 1944 Treaty may fall short of what is needed to guide policymakers through the process of reevaluating and reallocating water rights among all the dependent states. In order to reduce the risk of conflict among interested parties, new policies and/ or amendments may need to be drafted to prepare for the existing and predicted reality of supply versus demand of Colorado River water.

In the arid west, water is a limiting factor that affects the carrying capacity of the region. Cities can only grow to the extent that water is available. The carrying capacity of Baja California is almost entirely dependent on Colorado River water. Any reduction in the Colorado River water flow means a reduction in the carrying capacity of the state of Baja California. When carrying capacity decreases, human conflict is unavoidable (Read and LeBlanc 2003; Schwartz and Randall 2003) and then it becomes a matter of national security. Analyzing possible conflict scenarios for the Department of Defense, Schwartz and Randall (2003) point out that the most likely scenario will be that the U.S. will reduce the flows delivered to Mexico through the Colorado River, creating friction between the two governments. In the scenario of a catastrophic change in climate (as analyzed by Schwartz and Randall 2003), the United States turns inward, committing its resources to feeding its own population, shoring up its borders, and managing the increasing global tension.

The Earth's carrying capacity, which is the ability of the planet and its natural ecosystems to support life, is being challenged around the world. Technological progress has increased the carrying capacity for human populations over time. Over centuries, humans have learned how to produce more food and energy, and how to access more water. But will the potential of new technologies be sufficient when a crisis hits?

Historically, humans have conducted organized warfare for a variety of reasons, including conflict over resources and the environment. Humans fight when they outstrip the carrying capacity of their natural environment. Every time there is a choice between starving and raiding, humans raid. Peace occurs when carrying capacity goes up, as with the invention of agriculture, new management practices, and trade or technological breakthroughs. Population growth may be reduced below carrying capacity during peacetime, which can be the result of something as tragic as a large-scale dieback from disease. For example, in Europe after its major plagues, or in North America after European diseases decimated Native American populations, low population growth created peaceful periods between conflicts. But such peaceful periods are short-lived because population quickly rises to once again push against carrying capacity, and warfare resumes. Indeed, over the millennia most societies define themselves according to their ability to conduct war, and warrior culture becomes deeply ingrained. The most combative societies are the ones that survive (Read and LeBlanc 2003).

Conclusion

Diminishing water supply has the potential to generate international conflicts that will test the capacity of leaders on both sides of the border. Water allocations from the Colorado River will have to be renegotiated in the near future. The role of the International Boundary and Water Commission (IBWC) and its Mexican counterpart Comisión Internacional de Límites y Aguas (CILA) will be crucial in renegotiating water allocations for all of the Colorado River Basin. The stakes are different for both countries since it is likely that Baja California will be in a more desperate situation, due to near total dependence on water from the Colorado River and little or no availability of alternative sources.

Reductions in water use by the agricultural sector are already taking place on both sides of the border. Nonetheless, without an increase in availability, water for agriculture in Baja California will have to be reduced and the economic impact will be considerable. Moreover, Baja California has fewer options due, in part, to the fact that Mexican legislation places urban demand as the top priority for water allocation. Under Mexican legislation, only after the needs of urban users are met can the remaining water be allocated to agriculture. There is no system of redress for the revenue lost by farmers in the event of a shortage. Further, water delivery to farmers is contingent upon accessibility; if there is a failure in infrastructure such as the damage to irrigation channels in Mexicali caused by the 2010 earthquakes, water delivery to farmers can be interrupted and they do not receive compensation. California, however, has alternatives (although at a large ecological cost). In an extreme survival situation, border cities in California may use the water from the Sacramento River Delta. The position of Baja California in the event of a reduction of flow from the Colorado River is desperate and actions born in desperation may lead to conflict. The 1944 Treaty should be revamped to deal with this potentially explosive scenario.

It is important to remember that there are very strong ties between the societies of California and Baja California and that many positive actions take place at the local level, implemented by grassroots organizations from both sides of the border. For example, the Tijuana River Valley Recovery Team is a binational collaboration of more than thirty federal, state, and local agencies that was organized to implement recovery of the Tijuana River Valley (TRVRT n.d.). The U.S.-Mexico Border Environmental Program (Border 2012)—a collaboration between the U.S. Environmental Protection Agency (USEPA) and Mexico's Secretariat of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT)—intended to be utilized to improve the environment and protect the health of the nearly 12 million people living along the border, is a program that takes a "bottom-up" approach to addressing environmental and public health needs of the border region (USEPA n.d.). The risk of conflict could be greatly reduced if the communities on both sides of the border take steps to reduce the impact of future water scarcities and cooperate with each other locally. As of now, both the central governments of the U.S. and of Mexico will have to deal with this problem within the framework of the 1944 Treaty at a diplomatic level, but local actions will be fundamental to finding new, creative ways to cooperate in solving the common problem for the future of the region.

Endnotes

[1] The mainstem is the principal channel within a river system.

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VIII

Thirty Years of Groundwater Evolution—Challenges and Opportunities for Binational Planning and Sustainable Management of the Transboundary Paso del Norte Watersheds

Alfredo Granados-Olivas, Bobby J. Creel, Erick Sánchez-Flores, Javier Chávez, and John W. Hawley

Abstract

The border region between Mexico and the United States is one of the most populated areas in the world with close to 12 million people. All major watersheds in this border region are transboundary in nature where both surface and subsurface water resources are shared by these two nations. Groundwater is the main water resource in the Paso del Norte Region (PdN), which consists of Ciudad Juárez, Chihuahua; El Paso, Texas; and Las Cruces, New Mexico. Quantity, quality, and the hydrodynamics of groundwater sources in the PdN are major factors to consider in order to achieve holistic, sustainable development of water resources for the region. Because of aggressive regional development and urban expansion along the border in both countries, there is a need for a transboundary plan for binational groundwater management. It is critical to find common ground and to prevent future disagreements over water in the PdN.

INTRODUCTION

The border region between Mexico and the United States is one of the most populated areas in the world with close to 12 million people. All major watersheds in this border region are transboundary in nature where both surface and subsurface water resources are shared by these two nations. While official efforts are under way to develop a strategy for the intelligent use of these shared water resources, it is also well known that a thorough binational characterization of the system (a holistic approach to defining its geospatial distribution) is needed in order to have proper transboundary management of these water resources. There is a need to understand and evaluate the impacts that climate change may have on the surface and groundwater resources of the region, since climate change models predict dryer and sparser rainfall patterns for this already arid region. Furthermore, these models estimate more intense and geospatially localized torrential rains as a common form of precipitation, affecting recharge and increasing hydrometeorological risks in urban areas. Despite the fact that surface water managers have already put in place a plan to explore binational management strategies for groundwater, determining supply and allocation are challenging issues for Mexico and the United States to reach agreement on.

Groundwater is the primary water resource in the PdN, where binational understanding of factors affecting quantity and quality is necessary in order to achieve sustainable development for the region. Because regional development and urban expansion in the border region are ongoing economic objectives for both countries, there is a need to develop a framework for discussing sustainable use of this important transboundary resource. This paper identifies policy issues with regard to groundwater management and covers the historical evolution of groundwater studies within three major regional transboundary watersheds: The Mimbres-Los Muertos aquifer (NM-CH region); the Mesilla-Conejos-Médanos aquifer (NM-TX-CH region); and, finally, the Hueco Bolsón aquifer (TX-CH region). More specifically, these policies are analyzed with regard to the evolution of groundwater flow regimes within the watersheds. The evaluation of groundwater quality policies in these areas includes an identification of the different challenges and opportunities for binational cooperation on management of the watersheds and for data sharing. Also included are suggestions of different alternatives that could provide technical support and a foundation for a new transboundary water management agenda.

Water, People, and Areas of Opportunity for Sustainability

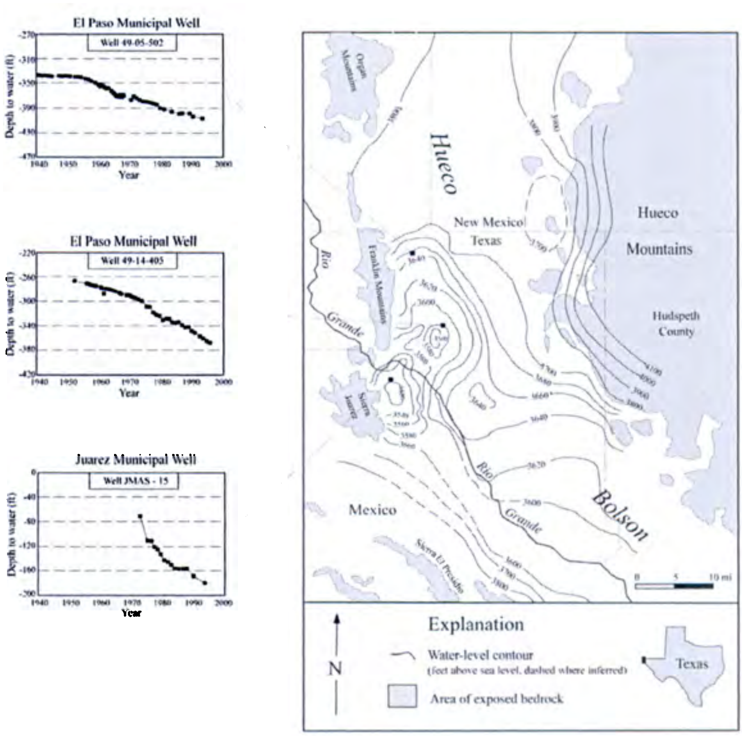
The PdN region is one of the most dynamic areas of the border, with high levels of border crossings by individuals and an impressive level of exchange of goods and services. These realities require infrastructure to facilitate them, which, in turn, affects border environmental quality in the PdN area. Rapid population growth has increased the demand for natural resources, such as water, and has led to unplanned changes in land use, all of which have negatively impacted the availability of these assets. In regard to groundwater, the natural trend of aquifer depletion reflected in the extraterritorially connected cones of depression is a known issue caused by this increased demand for the resource. Despite this challenging scenario, there are many areas of opportunity for this region that need to be explored to develop strategic plans for water resources and intelligent land use related to groundwater availability. Furthermore, emphasis should be placed on sustainable management of groundwater resources in relation to land use. Examining dynamics among overlapping factors is a more pragmatic approach to planning and will enhance the capacity to prevent future disputes over binational water management for the PdN region.

Demographics and Challenges for Sustainable Water Resource Management—PdN

Issues related to and causes of the population explosion along the border are well documented (Hurd et al. 2006; Ganster et al. 2000; Peach and Williams 2000). As the population growth continues trending upward and urban expansion remains a prominent feature of policy priorities in the PdN region, the demand for water resources will necessarily increase. Since binational water management and improvements in water use efficiencies are minimally considered by the water agencies of both nations as part of their strategic planning, there is a potential risk that these water resources will be exposed to a continuous depletion. This is demonstrated by the temporal evolution of groundwater levels in the PdN region, as shown in Figure 1, where cones of depression extend into both countries, acting as a single hydrogeological unit without consideration for the official geopolitical boundary at the border. The political boundary bisects the Hueco Bolsón, which serves as the main groundwater reservoir for the El Paso, TX-Ciudad Juárez, CH area. Hueco Bolsón is geospatially shared by the two nations, but water management policies are different across the border and the need to develop common criteria for pumping water in this region has not yet been addressed. The evolution of groundwater levels is shown in the graphics to the left in Figure 1, where some of the reference wells on both sides of the borderline show a continuous depletion on their piezometric water levels from 1940 through 1995.

Cones of depression located in the downtown areas of both cities—shown on the map in Figure 1—are some of the most important occurring hydrogeological phenomena. Focused depletions of groundwater levels are present in heavily pumped areas, pulling the groundwater flow toward these cones of depression from both sides of the border. This implies that groundwater quality has deteriorated over time, in part because the pumping is a causal agent of increased Total Dissolved Solids (TDS) concentrations in this transboundary region. This represents a potential health risk and the need to explore a more robust agenda for investing in groundwater treatment facilities such as desalination technologies like those utilized by the El Paso Water Utilities Desalination Plant. Improvement in treatment options will be necessary in order to meet groundwater quality standards and to provide the volume required to satisfy water demands of the region.

Figure 1. Groundwater Level Evolution in the Transboundary PdN



Source: Hibbs et al. 2003.

Academic Agenda for Transboundary Water Resources Research at PdN

Scholars and experts on water resources in the PdN region are aggressively researching possible scenarios for available groundwater in an effort to evaluate and define sustainable strategies for use of water resources in the region (Silva-Hidalgo et al. 2009; Eastoe et al. 2008; Granados-Olivas et al. 2008; Hawley and Granados-Olivas 2008; Hibbs et al. 2008; Creel et al. 2006; Granados et al. 2006; Hurd et al. 2006). The location, political and strategic management, geologic formations, and hydrodynamics of the PdN aquifers are considered in several research efforts guided by a common mission to understand the hydrogeologic phenomena occurring in the region. Nonetheless, there is need for more research as these studies identify potential areas of opportunity that could be explored to enhance the binational understanding of the aquifer formations within these areas of interest and to define new strategic approaches for binational groundwater management.

Physical Characterization of the PdN Transboundary Watersheds

One of the major tasks for improving transboundary groundwater management in the PdN is the physical characterization of aquifer extensions containing saturated deposits that hold the available groundwater for the region. Most of these "packages" of saturated sedimentary deposits are the product of thousands of years of geomorphologic evolution and a thorough understanding of their physical characteristics, geographic locations, and tridimensional extensions is required. The existing state of knowledge for the aquifer formations in the PdN is only half of the picture, since the methodical application of geological information—which would integrate the basin-fill arrangement with groundwater availability—is a task that remains to be undertaken. For example, groundwater flow models developed in recent years for the PdN do not integrate existing subsurface hydrogeological information with other transboundary groundwater dynamics considered in the models (Hawley et al. 2009; Hawley et al. 2000). Furthermore, descriptions of the groundwater systems have not been completed by the Mexican side of these transboundary watersheds. This deficiency could be eliminated in the near future by applying a methodological procedure for a long-term research agenda managed by the relevant water agencies and by integrating the ongoing agenda of existing binational academic efforts. Moreover, most official hydrogeologic and geohydrologic investigations on groundwater resources along the border represent the "white map" syndrome where geospatial extensions of geomorphic units are "cut" at the boundary of both countries. Other projects have provided exchanges of information, but leave out the additional effort to integrate geospatial information in a common binational geodatabase (Creel et al. 2006; Granados-Olivas et al. 2006; Hibbs et al. 1997).

Water Availability in the PdN and Neighboring Areas: The Hueco Bolsón, the Conejos-Médanos-Mesilla Bolsón, and the Mimbres-Los Muertos Basin

Resource managers, developers, and policymakers need to take present and future demands for water resources into account in order to plan for this rapidly growing region. There are different projections for water demands in the PdN region. Some short-term estimates consider the increase of water demands according to past evolution of registered consumption of water by different users in the watershed. Hence, it is estimated that demand for water by 2030 will increase according to population growth and urban expansion in the PdN region. Potential environmental impacts that are discussed as a part of these observations and projections—in particular, groundwater quality deterioration and depletion of groundwater levels—are major concerns. These concerns are compounded by the impacts of increased energy consumption that is necessary to continue pumping from deeper wells in the aquifers to the distribution lines located in the cities. Pumping groundwater from deeper locations in the wells could impact family budgets and the local economy. The areas likely to experience spikes in electricity rates are located in the urban areas of the PdN, as shown in Figure 1, where cones of depression created by heavy pumping are localized and specific depressions compared to the complete extension of the aquifer formation. In other words, deteriorated groundwater quality and depleted water table levels will exist within an acute area of the total geospatial extension of the aquifer formation and correlate with the major PdN urban areas. If demand, climate conditions, and pumping and delivery infrastructure remain constant, the deterioration of groundwater quality will worsen and the depletion of the groundwater table will deepen, extending the geographical expansion of the identified cones of depression to a broader area. This will force the need for more infrastructure to extract water from neighboring aquifer formations, thereby increasing the price of water services. Furthermore, the expansion of the well fields into rural areas will affect water availability and cost—and therefore the livelihood—of rural area residents where economic activity is predominantly based on agricultural and livestock production. This type of scenario is one that is not far from the current reality since a similar case study has identified this conflict of interests on the Conejos-Médanos Basin, on the west side of the Sierra de Juárez (Figure 1). A recent change in land use has forced cattle ranchers from their land in order to make space for a major Mexican groundwater project, the Conejos-Médanos Groundwater Project (CMGP), which will provide water and partially satisfy demands for Ciudad Juárez.

Despite this developing tragedy of the commons scenario, available groundwater resources in the PdN and surrounding areas—including sections of the main aquifer system found in the PdN region, such as the Hueco Bolsón, the adjacent aquifer formations of the Mesilla-Conejos-Médanos aquifer, and the Mimbres-Los Muertos Basin—are vast and have the potential to supply the region if utilized resourcefully (Hawley et al. 2009; Hawley and Granados-Olivas 2008; Eastoe et al. 2008; Hibbs et al. 2008; Creel et al. 2006; Granados-Olivas et al. 2006; Hibbs et al. 2003; Hawley et al. 2000; Hibbs et al. 1997). However, it is questionable whether the new CMGP and its battery of pumping wells is the most practical and sustainable plan for extraction from the aquifer, since there are no complete studies that verify the extension of the aquifer formation and its capacity to sustain groundwater pumping without generating new irreversible cones of depression, as the ones presently affecting the Hueco Bolsón aquifer formation. This could negatively impact the CMGP and could make it extremely difficult for water supplied by this project to meet water quality standards and established parameters necessary to serve as a public water source. The CMGP engineers and managers should develop a plan for evaluation and monitoring through mathematical modeling of the system that could keep track of changes occurring in the aquifer as a result of the heavy pumping. Unfortunately, the existing budget that was assigned to develop the infrastructure for the CMGP did not include funding to support a research team to study the system and keep track of changes in the aquifer. This represents a missed opportunity for the strategic and sustainable management of the aquifer and for monitoring the evolution of the groundwater system.

Climate Change Impacts on Transboundary Accessibility to Water Resources

Global warming and climate change are two major factors influencing the availability of both surface and groundwater. Climate change predictions and modeling assessments for the PdN, located in the Chihuahuan Desert ecosystem, estimate a dryer climate with intense torrential precipitation that is unevenly distributed and unpredictable. This could bring changes to the hydrologic phenomena occurring in the region where runoff will be subject to these immediate changes, leading to a potential reduction in annual/seasonal flow as a result of the sparse precipitation patterns. Moreover, intense precipitation events could overwhelm stream channels and become the source of hazardous runoff episodes in acute areas where the precipitation does take place. The storm events would reduce the time that water would remain concentrated at various locations in the watershed in relation to outlets, which could increase the risk for potential flooding and hydrometeorological hazards (Rojas-Villalobos et al. 2008; Granados-Olivas et al. 2007).

The time of residence of groundwater located within the confining saturated strata found at local aquifers has a broad-range spectrum on the geologic time scale and it also has a geospatial component. For example, studies on groundwater time of residence in the PdN found that the isotopic signature on tapped groundwater resources demonstrated that the Hueco Bolsón had an average time of residence of some 45 years at the Piedmont Slopes found close to hills on the Sierra de Juárez, whereas time of residence on the plains of the same aquifer formation were more than approximately 3,000 years (Eastoe et al. 2008; Hibbs et al. 2003). Also, groundwater quality and the potential to recharge these aquifers could be related to geomorphic features. For example, wells located close to recharge areas, such as arroyos and fracture traces located at the Piedmont Slopes within the Hueco Bolsón have lower TDS concentrations, providing a better groundwater quality (Granados-Olivas et al. 2005; Granados-Olivas et al. 2003). Hence, if climate change modifies precipitation patterns and the frequency of torrential rains falling within these regions, a change in availability and groundwater quality could be expected. Nonetheless, all these hydrogeologic scenarios need to be studied in more detail in order to determine how to manage these aquifers sustainably and binationally. A binational research agenda for studying PdN and surrounding water resources needs to be developed in the near future. This will require an agreement between the two nations covering long-term monitoring and exchange of data as well as logistical procedures for implementing a binational action plan. This plan will need to address issues such as definition of terms and units; scales of analysis; methodologies; language; and interpretation of existing policies and agreements. The framework for the binational research agenda will need to be based on the application of the current water legislation of both countries and the recommended actions should be based on scientific research results to achieve sustainable groundwater use in the borderlands.

Review of Mexican Water Law and Its Implications for a Transboundary Management Scheme

Article 4 of Mexico's Constitution states that "every person has the right to health protection" as well as "the right to an environment adequate for their development and wellness." As this also pertains to water, there are laws specifying that access to potable water is a basic human right for every Mexican citizen. These laws are enforced by special water agencies, such as the National Water Commission (Comisión Nacional del Agua–CONAGUA). This national water agency is responsible for managing and maintaining water resources for the entire country and it is regulated by the Law for National Waters (Ley de Aguas Nacionales–LAN[1]). Although it might be seen as an advantage to have a single, national agency regulating use and enforcing water laws, there are "big picture" competing interests that national agencies must balance (such as socioeconomic demands versus limiting use in the name of environmental protection), leading to a disconnect between federal management and the reality of what is needed to sustain and protect individual watersheds. For example, in the 1990s, Mexico initiated an effort to regulate all groundwater rights in the country, which required all users of agricultural water wells to report to local CONAGUA offices to register their perceived water rights. Agricultural wells on the Mexican side of the Mimbres-Los Muertos Basin in the Palomas-Guadalupe Victoria aquifer had not required permits previously and some of these water wells had been publically available for agricultural purposes since 1960 as part of an official effort to populate and develop the northern regions of Mexico. Moreover, no registration or documentation for the agricultural wells was required at the time of this colonization process. However, despite this free-for-all, as a part of this colonization program, piezometric levels of drilled agricultural wells were measured on two specific sampling dates during the year (winter and summer measurements) to monitor groundwater table evolution. The monitoring stopped in the early 1980s due to budget restrictions, but was reestablished in 2009 as part of a one-time effort to redefine the groundwater table evolution in the watershed.

During this period of approximately 30 years of unmeasured groundwater evolution and a lack of law enforcement, many new wells were drilled in the watershed, leading to significant depletion of groundwater levels in some areas, while other areas of the same aquifer remained at levels measured in the 1980s (Granados 2000; Granados and Monger 1999). Recently, the water authority of Mexico declared the Palomas-Guadalupe Victoria aquifer a "no-drilling zone," but without developing a plan for enforcement and without a strategic plan to prevent new drillings. This declaration to limit new agricultural well drillings was arrived at without scientific foundation or a study of how this could affect regional growth. A geodatabase could have been generated if groundwater data had been collected consistently over the past 50 years and this would have aided in making a more appropriate policy decision about how to deal with the aquifer depletion, rather than an across-the-board declaration for a no-drilling zone. Unfortunately, this declaration created unstable conditions and conflicts over water in the area because the Chihuahua offices of CONAGUA have taken an aggressive approach to halting new well development in the Los Muertos Basin region, and more specifically at the Palomas-Guadalupe Victoria aquifer. Part of the plan included cancelling water well permits and capping many of the existing agricultural wells, leaving local farming communities irritated and hopeless because authorities have taken an inflexible approach to determining that some wells are "unjustified." This is the wrong approach for CONAGUA to address the problem of non-census water wells because the data on groundwater budgets for the area used to justify these actions are incomplete.

Many of the hydrologic variables used to produce a water budget for the basin are wrong, out of date, or, even worse, "estimated" and not measured. For example, recharge in the basin is an important variable to take into consideration in order to estimate the requisite groundwater volume for achieving equilibrium in the system. However, this is not known for the region, leaving the option for a real groundwater budget incomplete. Furthermore, another important variable for developing a reliable estimate of available groundwater resources in the area would be to measure the volume of extraction from the local aquifer. This figure (volume of water pumped from the aquifer) should give the total amount of water pumped from all wells throughout a year, but the current procedure for estimating the total volume is based on the volume pumped from the permitted wells in the area, and not from actual yield measurements taken from all productive wells.

Because not all of the wells are registered and most of the registered wells do not have a flow meter integrated as part of the water well design, CONAGUA calculates the "available volume of groundwater" for the basin based on the allocated groundwater permits without taking an actual measurement of the volume extracted from all wells in the basin. This procedure produces misleading information and complicates the possibility for creating a suitable policy to reach successful groundwater sustainability for the area. Furthermore, these actions have impacted the livelihoods of farmers and family agricultural businesses, resulting in abandonment of their properties and emigration to other areas in the basin, to cities, and even across the border to the U.S. looking for a better quality of life.

So, are We Ready for a Binational Groundwater Treaty?

No, we are not. Mexico has much work to do on developing a sustainable management plan for groundwater resources, including gathering sufficient data on aquifer formations, improving expertise in understanding and applying existing water policy, and creating a system for allocating resources fairly to users on its side of the border. Until these deficiencies are resolved, no official authority responsible for the administration of water resources in Mexico will have the ability to accurately define its position at a binational meeting with regard to allowable volumes of extraction within its territory. First, Mexican water authorities need to make it a priority to gather the data necessary for a complete picture of the existing groundwater and aquifer formations on its side of the border. Second, CONAGUA needs to resolve the discrepancies between water use and enforcement of the current water law within its own territory. Quantifying and mapping the geospatial distribution of groundwater available within the transboundary watersheds, and perhaps reorganizing the structure of water institutions so that they are more ambitious, pragmatic, and efficient in solving these issues will increase the likelihood that Mexico would be able to work with the U.S. toward a sustainable, binational groundwater treaty to serve both nations in the 21st century.

Summary

In order to establish an appropriate binational management strategy for surface and groundwater resources in the PdN, water authorities in the region must complete an assessment of demand, recharge rates, and existing water table levels. In addition, policymakers and water resource managers must work together to reevaluate and improve the functionality of water policy serving the region by completing a comprehensive analysis of how to best utilize the regional water supply to meet various competing needs. This will require an evaluation of social, economic, and environmental factors unique to this region. Emphasis should be placed on the need to analyze groundwater resources and management on the Mexican side of the watersheds. It is important to note that many of the issues discussed are also the subject of ongoing research agendas. The results of this research will eliminate some of the existing data deficiencies, bringing the two nations closer to being able to develop a binational agreement for water resource management for the region. However, binational administration of groundwater resources is not possible in the short term because many important factors need further study, specifically on the Mexican side of the watersheds. In order to speed up the process for establishing a binational management scheme, both nations should support interdisciplinary teams of binational experts to evaluate potential scenarios for sustainable use and management of water resources in the PdN by defining a common vision for a "steady state of equilibrium" for regional water resources.

Endnotes

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IX

Air Quality at the U.S.-Mexican Border: Current State and Future Considerations toward Sustainability

Gabriela Muñoz-Meléndez, Margarito Quintero-Núñez, and Ross Pumfrey

Abstract

Many residents of the U.S.-Mexican border region are currently exposed to health-threatening levels of air pollution, especially ozone (O_3), particulate matter (PM), and carbon dioxide (CO_2). This situation has created concerns on both sides of the border. On the American side, the U.S. Environmental Protection Agency (EPA) and the four border states have developed regional strategies to address the problems. On the Mexican side, the National Institute of Ecology (Instituto Nacional de Ecología–INE) has also developed strategies. The two nations have separate but similar ambient air quality standards, yet air pollutants move freely across political borders. Because of physical conditions such as topography, geomorphology, and weather, border communities share airsheds in which the distribution of pollution is affected by changing wind patterns depending on the season. Human activity that generates pollutants on one side of the border will usually have an impact on the other side. Binational airsheds, therefore, pose additional management challenges because of legal and other differences between two sovereign countries.

Using the available literature as well as their own knowledge based on years of participating in meetings, strategic planning, and analysis, the authors examine the socioeconomic aspects of this border region; what is known about particular air pollutants; what actions have been taken by governments and others and what are the results; and to what extent cooperation at the federal and state levels has been undertaken. Finally, they offer selected recommendations.

INTRODUCTION

Air pollution can be a serious threat to public health. Maintaining good air quality is a serious challenge to almost all nations. Complex systems of regulations and administration have been established to address this challenge that becomes even greater when neighboring countries, each with its own legal system, literally share the causes and effects of particular cases of air pollution because of split airsheds.

Borders serve as legal, economic, and administrative dividing lines between nations. As such, they set both the territorial and jurisdictional limits of nation-states and, hence, of national sovereignty. Borders may serve as "barriers" or as "points of contact and integration" between the people and systems of two (or more) adjacent countries, depending on the degree of openness between neighbors. Along relatively closed international boundaries, the border will serve as a barrier; along relatively open boundaries, it will spark integration (Hansen 1994).

Regions adjacent to international boundaries are likely asymmetrical in one or more of the following areas:

- Geography: resources, topography, built environment
- Demography: age structure, growth rate, size, ethnicity, density per unit of land
- Economy: factor endowment (available input) and output structure, long-term growth rate, development
- Political system: centralization or decentralization, organization of government functions, legal systems, common practice
- Culture: history, ethnicity, language, customs

Geographic and economic asymmetries can generate transboundary commerce in the form of formal and informal networks for exploiting potentially profitable business opportunities. Political and cultural asymmetries, by contrast, can serve as obstacles to transboundary collaboration. The economies of neighboring regions are frequently complementary in the structure and cost of both inputs (characteristics of the labor force, natural resources, capital, and entrepreneurship) and outputs (final goods and services).

This paper examines how these phenomena are played out in the border region of Mexico and the United States. It also analyzes how air quality is managed in that context and what strategies have served or could serve to improve air quality in this region. The objectives of this paper are fourfold: (1) to describe the border context; (2) to examine the current and anticipated status of air quality in this region; (3) to summarize what has been done both unilaterally and collaboratively thus far by the governments on both sides of the border to manage air quality issues; and (4) to analyze and propose additional actions that could improve air quality in the border region. In order to achieve these objectives, this paper is divided into five parts:

1. Socioeconomic characteristics of the border
2. Air quality: Management and current status
3. Potential air quality issues through 2030
4. Transboundary cooperation
5. Observations and recommendations

The first part presents a brief review of the border region. It analyzes the social and economic reasons behind the air quality degradation in the region and how these, if left uncontrolled, could become obstacles for achieving a sustainable environment. The second part describes the main air pollutants and current air quality in the U.S.-Mexican border region; it also summarizes how air quality is managed in the two countries. The third part describes potential issues in 2030 based on emissions forecasts, and reviews briefly the potential effects of climate change on the generation of O_3 and PM. The fourth part describes the formal governmental collaboration that has taken place to address the shared air quality problems, principally, but not entirely, based on the framework of the 1983 U.S.-Mexico La Paz Agreement and its current programmatic elaboration, Border 2012.

Finally, the paper offers conclusions and recommendations related to the achievement of sustainable air quality in the binational U.S.-Mexican border region.

Characteristics of the U.S.-Mexican Border Region

Overview of the Border Region

The border that divides Mexico and the United States has a length of 3,141 km. From both countries' perspectives, the main objective for the border is to be selective with respect to the transit of people as well as trade. This selectivity, however, does not apply to transboundary air, water, and land pollutants at any point on its entire length, extending from the Pacific Ocean to the Gulf of Mexico. The Mexican-U.S. border region is defined officially by the binational La Paz Agreement as the territory situated within 100 km (62 miles) north and south of the borderline, as shown in Figure 1. This region includes 25 counties in California, Arizona, New Mexico, and Texas on the U.S. side and 35 municipalities in Baja California, Sonora, Chihuahua, Nuevo León, Coahuila, and Tamaulipas on the Mexican side.

This region has a highly complex network of relationships between the two countries that encompasses shared natural resources, social and cultural links, and economic transactions. These relationships have not always been voluntary and in some cases have had unintended or not fully thought out consequences. This aptly describes the relationship that border region inhabitants have with much of their environment, a relationship that at best could be considered problematic given the widespread and often accelerating deterioration in the border zone.

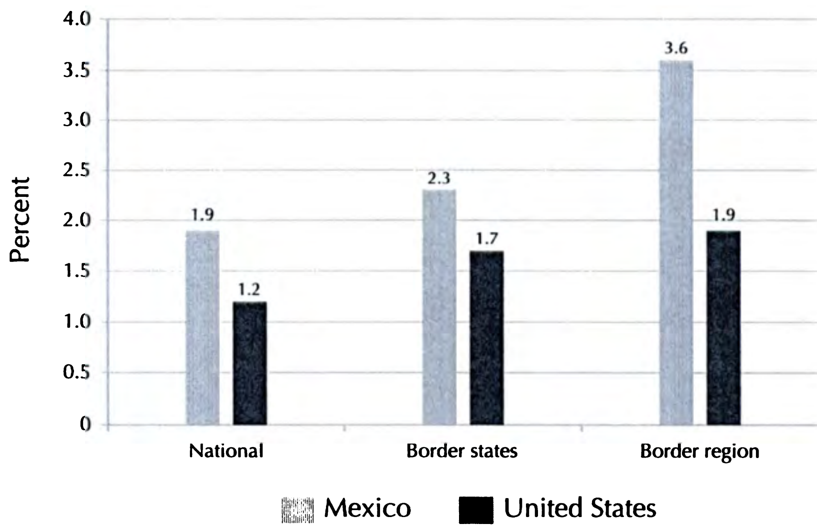
Figure 1. The Mexican-U.S. Border Region Defined by the La Paz Agreement

Socioeconomic Aspects of the Border Region

In 1983, the La Paz Agreement was signed by Mexico and the United States to address the need for cooperation on the protection and improvement of the border region's environment. There were growing concerns over the increasing environmental degradation in the metropolitan zones in the border region, which was a direct result of accelerated population growth in the absence of well-planned development, and the pressure of an increasing demand for services, more traffic, and greater generation of waste. The environmental degradation was not limited to the cities but also reached rural communities in the form of drainage discharges to arable land, generation of dust, exposure to pesticides, inadequate water supply, insufficient or nonexistent sanitation, and other phenomena. Growing air pollution from smelter emissions in parts of the border was especially of concern and attracted widespread attention by regional residents and the policy community.

Although population growth occurs on both sides of the border, annual rates have been higher on the Mexican side, as shown in Figure 2. The border population has particular demographic dynamics that are very much influenced by internal migration in Mexico. Mexicans have migrated to the northern border because they have perceived it as prosperous, or because they have considered themselves to be temporarily in the area and on their way to the United States. According to the 2005 Census of Population and Housing in Mexico, the Mexican border region population was 7,089,185; this figure represented 39% of the total population of the six border states, and nearly 7% of the national total population. In comparison, in 1995 these figures were 35.8% and 6%, respectively (González 2009).

Figure 2. Average Annual Population Increases in Mexico and the United States, 1990–2000



Sources: U.S. Census Bureau and Mexican Census of Population and Housing, Summary population and housing, PHC-1-6.

The perceived prosperity in the Mexican border region was based largely on industrial development, which increased even more with the implementation of the North American Free Trade Agreement (NAFTA) beginning in 1994. In Mexico, the border region has had the lowest unemployment rate and the highest salaries. Economic growth clearly has generated jobs, but such growth has not been accompanied by a complementary increase in infrastructure (such as water-related facilities and roads) and pollution control. This unbalanced development has led to an unsustainable use of natural resources, with the result that environment and public health are being affected on both sides of the border.

Currently, 12 million people inhabit the border region, and it is estimated that this number will double by 2025. Therefore, it is a priority to guarantee the well-being of inhabitants and their environment alike. This would require that all future development not only be economically viable, but also be accompanied by social and environmental perspectives that consider the sustainable use of natural resources.

Maquiladora Industry

Two historical factors were associated with the initial development of the maquiladora (assembly factories) industry in the Mexican border region: the cities' locations and their status as duty-free zones. The combined effect of being far away from the rest of the Mexican Republic and the existence of a duty-free zone in the region since the 1930s discouraged the establishment of Mexican companies for many years.

In this context, the consumption of imported products was favored, thus limiting the region's integration with the rest of the Mexican national market. This tendency affected the development of industry in the border states until 1965, when the Border Industrialization Program (BIP) was created to promote the development of maquiladoras in the region (Ranfla et al. 2005). In its first phase, the BIP was limited to duty-free zones and border regions and hence concentrated maquiladoras in northern Mexico.

In the first decade of the twenty-first century, the maquila industry in the Mexican border region has been at a crucial juncture due to two factors: (1) relatively small local and regional demand; and (2) competition with Chinese producers. This new situation poses a challenge to industrial growth in the region, calls for a diversification of the regional economy, and demands important changes in the development and organization of the entire region.

Brick Kilns

In Ciudad Juárez, in 2003, there were approximately 350 primitive kilns used to manufacture bricks (Erickson et al. 2004). These kilns used open-fire structures that were fueled by burning wood, sawdust, tires, refuse, and other combustibles. They emitted large clouds of soot, carbon monoxide (CO), nitrogen oxides (NO_X), and volatile organic compounds (VOCs).

Roberto Marquez of New Mexico Sate University—with SCERP funding as well as support from EPA through a grant managed by the Texas Commission on Environmental Quality (TCEQ)—developed the Marquez kiln, an alternative technology that substantially reduced emissions. In the Marquez design, two identical kilns are built adjacent to each other and connected by an underground tunnel. One kiln is fired and its effluent is vented through a tunnel to the second kiln, which has been filled with green brick. The clays in the green bricks serve as a filter and absorbent, substantially reducing emissions. Moreover, the waste heat helps cure the second kiln's bricks. The Marquez kiln is cleaner, more efficient, and less costly to operate, and the construction involves materials and techniques already used in the construction of primitive kilns.

To enable a unique opportunity for cross-border emission trading, the Texas legislature passed a law in 2001 that allowed El Paso Electric (EPE), the private electricity utility in El Paso, Texas, to meet special state requirements (not federal requirements) of emission reductions by obtaining credits from activities in Ciudad Juárez. EPE paid for replacement of 20 traditional bricks kilns with Marquez kilns and obtained approval from the TCEQ to use the emission reductions from five of them to complete its obligation.

Infrastructure at the Border

As mentioned previously, development of infrastructure has generally not kept pace with population growth, and this has negatively affected the environment. There have been some improvements, however, related to street paving and ports of entry.

Street Paving

High PM concentrations represent one of the main environmental problems in the border region. A significant source of PM is unpaved roads on the Mexican side. Some border states such as Baja California have addressed this problem. For example, in 2003 the General Directorate of Ecology (Dirección General de Ecología) (now the Secretariat for Environmental Protection [Secretaría de Protección al Ambiente]) of Baja California worked with the Ministry of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT), the Border Environment Cooperation Commission (BECC), and the North American Development Bank (NADB) in a successful effort to obtain financing for street paving.

Ports of Entry

Ports of entry at the border itself, where drivers of all passenger vehicles and commercial trucks must stop and present appropriate documents, are often congested. The idling of the vehicles is a source of air pollution. There are 39 ports of entry in the border region, with a total number of lanes allocated as follows: 73 for pedestrian crossings, 215 for passenger vehicles, and 83 for commercial trucks.

Financing development at the ports of entry is a considerable challenge because of the need to modify regulations and agreements as well as to ensure public-private participation for purposes of financing. Some of the proposed mechanisms for financing new infrastructure at ports of entry are fees, taxes, or other incentives for private investors, and public-private investment. Improvements and additions to this infrastructure are merited not only for the reduction of emissions from idling vehicles but also for economic reasons, as a study by Fuentes and del Castillo (2007) showed.

This study considered the two largest ports of entry in the border region—San Ysidro and Otay Mesa—because of their commercial importance. Waiting times at these ports are the longest (see Table 1). This affects approximately 64 million pedestrians, 5.5 million passenger vehicles, and one million commercial vehicles annually that cross these ports of entry on their way from Tijuana to San Diego. Commercial cargo trucks only cross into the United States at the Otay Mesa Port of Entry.

Table 1. Average Waiting Times at San Ysidro and Otay Ports of Entry, in Minutes, 2007

Category	0-60	60-90	90-120	120-150	150-180	180-240
Pedestrians	60%	12%	10%			
Vehicles	3%	38%	28%	26%		
Trucks	3%	24%	21%	24%	10%	10%

Source: Fuentes and del Castillo 2007.

Congestion causes additional costs to trade. For example, the annual direct costs of 745,975 vehicles waiting for three hours is $139,870,200 each year, or $466,236 per day (Fuentes and Castillo 2007).

Air Quality: Management and Current Status

Pollutants degrade air quality. Air pollutants are substances that, in high enough concentrations, harm human health and sometimes also damage other parts of the ecosystem or materials. These pollutants are quite diverse, but can be classified or characterized in several ways, as primary or secondary, by physical or chemical characteristics, by source, by environmental fate, and by effect.

The physical characteristics of a pollutant can be classified as solid, liquid, or gas, and by size in the case of particulate matter. An added complexity related to both the source and the chemical characteristic is that a particular pollutant may be classified as primary (directly emitted from an original source) or secondary (the product of a chemical reaction of emissions after they are in the atmosphere, as in the case of ozone). Finally, another classification is based on the effect of specific air pollutants in the atmosphere on incoming radiation, which, in turn, can have direct or indirect effects on human health. Pollutants leading to ozone depletion and greenhouse gases are the prime examples of indirect effects.

Given the ample range of air pollutants and their sources, nature, and effects, adopting efficient regulatory and management systems of air quality is of fundamental importance (Farmer 1997). Typical management approaches in the United States and Mexico involve several sets of activities. The first set of activities normally undertaken is the identification of the effects of various pollutants and a determination of which of the pollutants are most threatening and therefore in need of management and control. The next set of activities is the establishment of ambient standards for those pollutants considered to be current or imminent threats.

A subsequent activity focuses on monitoring the ambient concentrations in any geographical area where there is a suspicion that concentrations of one or more pollutants may be threatening. After determining which areas are suffering from violations of one or more standards, another series of activities is carried out to address the problem in each of those areas. These activities include the development of emission inventories, identification of possible control strategies, modeling to determine which strategy or combination of strategies will most effectively address the problem, and then implementation of the selected strategies. The strategic plans in the United States are called State Implementation Plans, or SIPs.

How the United States and Mexico are carrying out these activities, and what is known about the current status of air quality in the border region, are explained in more detail in the following sections.

Criteria Pollutants and National Ambient Air Quality Standards

Of the myriad of air substances known to be harmful to human health and welfare, some have been identified as being sufficiently hazardous and present in the air in sufficient quantities to merit enforceable standards. The United States and Mexico have independently developed and adopted such standards in the form of the National Ambient Air Quality Standards (NAAQS) and the Mexican Official Norms (Normas Oficiales Mexicanas–NOMs), respectively. In addition, through programs such as Border 2012 the countries have cooperatively developed specific objectives and indicators of progress for the border region.

Acting under the framework established by the federal Clean Air Act in the United States, during the 1980s and 1990s the EPA set standards for six categories of pollutants: ozone, carbon monoxide, total suspended particulates (more recently labeled particulate matter), sulfur dioxide, lead, and nitrogen oxide. Because of the particular criteria used to identify these pollutants—principally based on health effects—these are called the criteria pollutants.

Mexico has also identified the same criteria pollutants and established its own ambient air quality standards (the NOM). Over the past 20 years, both countries have on several occasions increased the strictness of these standards in response to continuing research on the effects of pollutants on public health and on ecosystems. The most recent AAQS for both countries are shown in Table 2.

Before comparing the AAQS values shown is Table 2, two aspects related to the U.S. standards should be explained further. The first is that values for U.S. NAAQS depicted in Table 1 correspond to primary standards that are set to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.

The second aspect of the U.S. NAAQS that merits explanation is the "attainment" concept. When the measured concentrations of a pollutant do not exceed a standard for that pollutant in a geographical area (such as a city or metropolitan area), then that area is considered to be in a status of attainment. When the concentrations measured by any monitor in a geographical area exceed a standard, then the area is designated to be in nonattainment status for the particular standard. An area may be in attainment status for one pollutant standard and in nonattainment status for another. In addition, the extent to which a particular standard is violated (meaning the severity of the violation) can lead to an additional level of designation, using the terms marginal, moderate, serious, severe, and extreme. States must design and implement a set of control measures (including some specific measures that are required under federal law depending upon this severity classification) in order to bring the area back to a status of attainment.

Table 2 demonstrates that the AAQS for the two countries are quite similar in most of the cases. This similarity between the two regulatory systems makes cross-border collaboration easier in the border region. But this convergence has not been the result of a one-time phenomenon. As has been mentioned, standards in each country have become stricter over the past 20 years. Modifications in U.S. NAAQS have usually come first, followed over time by modifications to the Mexican NOMs. The relatively recent development of $PM_{2.5}$ standards is a good example of this sequence.

In addition to the criteria pollutants and the related NAAQS, the U.S. Clean Air Act requires the EPA to develop rules related to visibility degradation in particular types of geographical locations—principally national parks. This type of visibility problem is mainly caused by $PM_{2.5}$ and usually is the result of relatively long-distance transport (via wind) of that category of pollutants, rather than local emissions. This aspect of air quality management, for example, is pertinent to Big Bend National Park in the border region of Texas.

The following section looks more closely at one aspect of that cross-border collaboration—the regional air quality indicators that have been developed cooperatively. A subsequent section will then discuss the application of the standards just summarized, identifying the geographical areas that have been in nonattainment status.

Other Related Indicators of Air Quality for the Border Region

The current U.S.-Mexican binational, multimedia environmental program is called Border 2012 (see subsequent section in this paper on transboundary cooperation). One of the six goals of Border 2012 is to reduce air pollution through implementation of specific projects in the four U.S. and six Mexican border states.

Border 2012 has established indicators to track general environmental conditions and trends and to evaluate the effect of the implementation of programs and projects. In the "State of the Border

Table 2. Comparison of Ambient Air Quality Standards (AAQS) in the United States and Mexico, as of February 2010

Pollutant	Averaging Time	U.S. NAAQS	Mexico NOM
Carbon monoxide (CO)	8-hour	9 ppm (10 mg/m³)	11 ppm (12.6 mg/m³)
	1-hour	35 ppm (40 mg/m³)	
Lead	3-Month Average	0.15 µg/m³ (October 15, 2008)	1.5 µg/-m³
	Quarterly Average	1.5 µg/m³	
Nitrogen dioxide (NO_2)	Annual (Arithmetic Mean)	0.053 ppm (100 µg/m³)	
	1-hour	0.100 ppm	0.21 ppm (395 µg/m³)
Particulate Matter (PM_{10})	24-hour	150 µg/m³	120 µg/m³
	Annual	50 µg/m³	50 µg/m³
Particulate Matter ($PM_{2.5}$)	Annual (Arithmetic Mean)	15.0 µg/m³	15.0 µg/m³
	24-hour	35 µg/m³	65 µg/m³
Total suspended particulates (TSP)	24-hour		210 µg/m³
Ozone (O_3)	8-hour	0.075 ppm (2008 std)	0.08 ppm (1993 std)
		0.08 ppm (1997 std)	
	1-hour	0.12 ppm	0.11 ppm
Sulfur dioxide (SO_2)	Annual (Arithmetic Mean)	0.03 ppm	0.03 ppm (79 µg/m³)
	24-hour	0.14 ppm	0.13 ppm (341 µg/m³)

Note: Units of measurement for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m³), and micrograms per cubic meter of air (µg/m³).
Sources: EPA, SEMARNAT, and Mexico's Ministry of Health.

Region Indicators Report 2005" (SEMARNAT and EPA 2006), the Border Indicators Task Force (BITF) presented the following air quality indicators:

1. Number of days exceeding air quality standards in border monitoring areas
2. Ozone concentrations in the border region
3. Particulate matter (PM_{10}) concentrations in the border region
4. Prevalence of physician-diagnosed asthma in Calexico-Mexicali

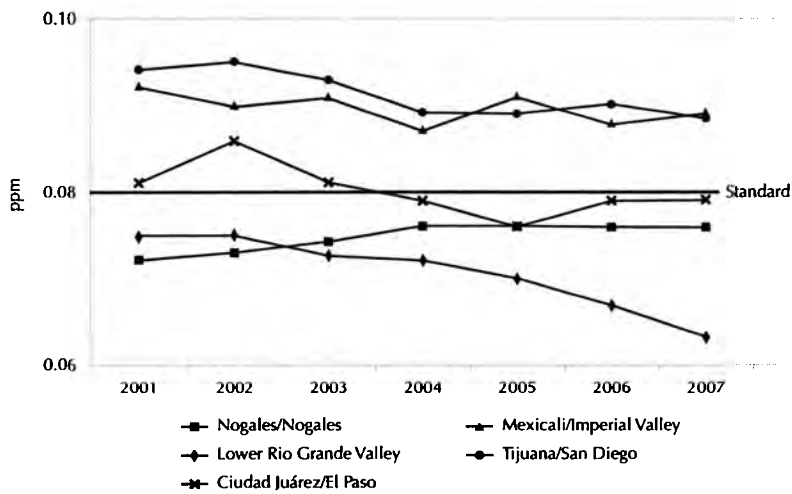
The first three indicators are closely related to the measurements that are used to determine violations in the two countries and therefore attainment designations in the United States.

In 2008, this report was updated. Data were added for 2006 and 2007 and, following binational discussions, two modifications were made to the indicators:

1. The indicator related to the prevalence of physician-diagnosed asthma in Calexico-Mexicali was removed. Despite the abundance of information regarding asthma prevalence, a comparison was not possible due to the lack of a common format—the two countries and even the border states have differences in reporting mechanisms and in defining the disease.
2. Indicators such as the existence of emission-reduction strategies, greenhouse gas emissions, and results of specific emission-reduction projects were added.

Three of the indicators of border air quality are based on direct measurements of ambient concentrations by monitoring stations in five geographic areas where there have been monitors on one side or both sides of the border since at least 1999. These are: (1) Tijuana-San Diego, (2) Mexicali-Calexico, (3) Nogales-Nogales, (4) Ciudad Juárez-El Paso, and (5) the Lower Rio Grande Valley (the southeast corner of Texas). Nine years of measurements, reflecting the data behind the U.S. nonattainment designations, show that the most persistent and pervasive pollutants found in the border region have been ozone and particulate matter (PM_{10}), as seen in Figures 3 and 4.

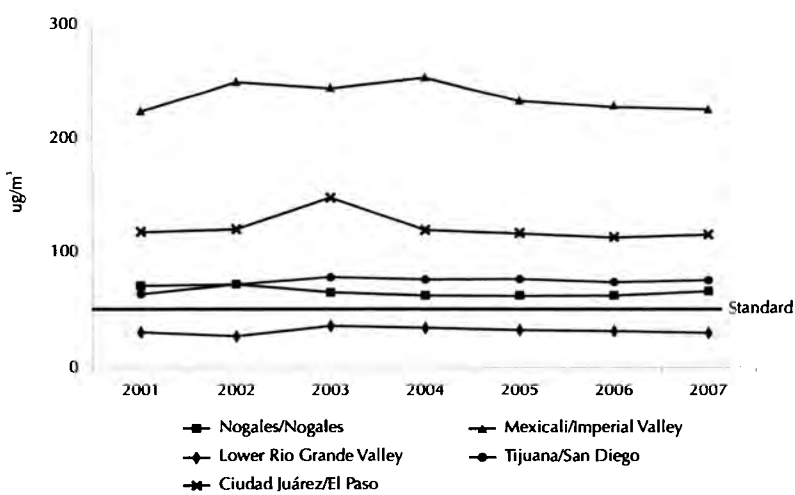
Figure 3. Averaged Ozone Concentrations in the Border Region



Note: Average of fourth highest value over three years.

Source: EPA Air Quality Systems (AQS) Database (www.epa.gov/ttn/airs/airsaqs/overview.htm).

Figure 4. Averaged PM_{10} Concentrations in the Border Region



Note: Three year average of annual mean concentrations at highest site

Source: EPA Air Quality Systems (AQS) Database (www.epa.gov/ttn/airs/airsaqs/overview.htm).

Air Quality Management in the Border Region

Once the standards have been established, air quality management in the United States and Mexico involves five sets of activities: ambient monitoring, determination of geographical areas that have air quality problems; development of emissions inventories; modeling; and selection and implementation of control strategies. EPA and SEMARNAT have, to varying degrees, made use of all five approaches.

Monitoring

According to Mexico's National Air Quality Information System (Sistema Nacional de Información de la Calidad del Aire–SINAICA), there are monitoring stations in two Mexican border states: Baja California (one in Rosarito, four in Tijuana, one in Tecate, and six in Mexicali) and Chihuahua (13 in Ciudad Juárez). In addition, the EPA has supported monitoring stations in three municipalities in Sonora—San Luis Río Colorado, Nogales, and Agua Prieta—as part of binational studies (described in a later section on transboundary cooperation).

In contrast, the EPA's ambient air quality monitoring program is delegated to the states; in many cases, the states have, in turn, delegated some of this authority to local governments. There are three major categories of U.S. monitoring stations that measure the criteria pollutants: state and local air monitoring stations (SLAMS); national air monitoring stations (NAMS); and special purpose monitoring stations (SPMS). Additionally, a fourth category—Photochemical Assessment Monitoring Stations (PAMS)—that measures ozone precursors (approximately 60 volatile hydrocarbons and carbonyl) was required by 1990 amendments to the Clean Air Act.

Stations on the U.S. side of the border are principally SLAMS. These are part of the network of approximately 4,000 monitoring stations nationwide whose size and distribution are largely determined by the needs of state and local air pollution control agencies to meet their respective SIP requirements.

Determination of Attainment Status

The monitoring of the various criteria pollutants has enabled the United States and Mexico to determine the geographical areas that are not able to meet the standards that have been established.

Because of the nature of airsheds, residents on both sides of the border in twin cities share the same air quality. Measurements taken on either side can generally serve as a proxy for conditions on the other side, and U.S. designation of attainment or nonattainment status can be interpreted from this perspective. Figures 3 and 4 show how air quality in selected border airsheds has compared to the standards.

Measurements show that the severity of violations of ozone and PM_{10} standards has varied geographically. Thus, the two areas in Baja California-California—Tijuana-San Diego and Mexicali-Imperial Valley—were most severely in violation of the ozone standard (Figure 3) and Mexicali-Imperial Valley has had the most severe problem with PM_{10}, followed by the Ciudad Juárez-El Paso region in Chihuahua-Texas. The Nogales-Nogales area in Sonora-Arizona has a less severe problem with PM and no violations of the ozone standard. The Lower Rio Grande Valley has not violated any of the standards.

Table 3 uses the U.S. designations of the severity of violations to characterize these airsheds, reflecting the relative numerical values shown in Figures 3 and 4, and adding information about sulfur dioxide (SO_2) in one of those airsheds and the problem of visibility in Big Bend National Park.

As discussed, the designation of an area as nonattainment in the United States triggers a series of measures to identify sources of pollution and develop control strategies. These topics are described in more detail in subsequent sections.

Inventories and Modeling

In order to have the data that allow for development of the most effective control strategies for areas that violate one or more federal standards, agencies determine the sources of each pollutant or class of pollutants and develop emission inventories. The inventories typically use four categories of sources:

Table 3. Airsheds in Nonattainment Status in the Border Region

Airshed	O_3	CO	PM	SO_2
San Diego-Tijuana	8 hrs			
Imperial Valley-Mexicali	Marginal (1 & 8 hrs)		Moderate	
Yuma-San Luis Río Colorado			Moderate	
Nogales-Nogales			Moderate	
Douglas-Agua Prieta			Moderate	Primary
El Paso-Ciudad Juárez	Under review		Moderate	
Big Bend Park Region	Visibility concerns*			
Lower RG Valley				

* Visibility degradation is principally a result of PM.
Source: The Green Book Nonattainment Areas for Criteria Pollutants, EPA: http://www.epa.gov/oar/oaqps/greenbk/.

1. Point sources (defined as stationary sources with emissions above a certain threshold, including facilities such as power plants, incinerators, refineries, and large factories).
2. Area sources (stationary sources that are too small to be listed and tracked individually as "point" sources, but which can be estimated and tracked as a class, such as dry cleaners, gasoline service stations, or wildfires).
3. Mobile sources (usually divided into on-road mobile sources, such as vehicles, and non-road mobile sources, such as airplanes, ships, and mobile farming equipment).
4. Biogenic sources (pollutants emitted by flora).

Inventories of the Mexican Border States

In 2004, the National Institute of Ecology (Instituto Nacional de Ecología–INE) unveiled the first air emissions inventory for the six Mexican northern border states (Inventario de Emisiones de los Estados de la Frontera Norte–IEEFN), using a base year of 1999.

This baseline emissions inventory was developed to improve the understanding of emissions sources located in northern Mexico and to support air quality assessments. The IEEFN is a product of binational government partnerships completed through collaborative efforts between the United States and Mexico.

The IEEFN considered all the criteria pollutants, as well as volatile organic compounds (VOC) and ammonia (NH_3) arising from both natural and anthropogenic point and area sources. Estimations showed that VOC was the air pollutant most abundantly emitted in the region, with up to 4,365,100 tonnes (metric tons) annually, of which 88% came from natural sources and 46% occurred specifically in Chihuahua.

CO emissions totaled 1,264,500 annual tonnes; 73% of these emissions came from on-road vehicles circulating in Nuevo León. PM emissions, including $PM_{2.5}$ and PM_{10}, totaled 1,059,300 annual tonnes. PM_{10} sources were identified as fugitive dust, and the sources of $PM_{2.5}$ were power plant and industrial activities. PM emissions were especially high in Nuevo León.

SO_2 emissions were 708,600 annual tonnes; 70% had their origins in power plants located in Coahuila, Sonora, and Tamaulipas. NO_2 generation was 687,300 annual tonnes; around 43% from natural sources and the rest came from power plants and vehicles. NO_2 sources were found in Coahuila. NH_3 was emitted at a level of 189,000 annual tonnes, and the main sources were livestock and agricultural activities, especially those carried out in Sonora and Chihuahua.

Inventories of the U.S. Border States

EPA updates the U.S. National Emissions Inventory (NEI) every three years, and much of the data is generated by state agencies. The most recent base year is 2008. The NEI contains detailed information about sources of criteria pollutants and their precursors (VOCs and nitrogen oxides) and ammonia (NH_3), as well as 188 additional hazardous air pollutants that are not criteria pollutants.

The NEIs make it possible to identify common sources of criteria pollutants. CO, VOC, and NO_x are released during fossil fuel combustion—principally vehicle engines, power plants, and boilers.

In addition, VOC sources include vapor releases during handling of fuel storage and the use of solvents. The main source of SO_2 is the combustion of those fossil fuels with high sulfur content. PM is also emitted during fossil fuel combustion, although additional primary sources are mechanical processes of pulverization and erosion of soils, rocks, and minerals. $PM_{2.5}$ sources are mechanical processes and suspension of soil and mineral particulates. Lead (Pb) is emitted as particulate matter from industrial processes and boilers, and a small Pb fraction comes from the aviation industry, as lead additives are used in aviation fuel. Finally, the dominant sources of ammonia are farm activities, in particular the use of fertilizers.

The 2005 NEI results in the U.S. border states showed that NO_x and SO_2 were the predominant emissions from stationary sources, followed closely by CO, PM, VOC, and NH_3, in descending order. Texas was the U.S. border state with the largest volumes of emissions of CO, VOC, SO_2, PM, and NO_x, because of the combined factors of population and industrial activities. Farms and use of fertilizers in California were the main source of ammonia emissions. Mobile sources in the region generated the most CO and PM emissions; 80% of these sources were located in California and Texas.

Binational Inventories

Examples of combined binational inventories (supported by sampling, modeling, and risk assessment) are limited to Arizona-Sonora, where the Arizona Department of Environmental Quality (ADEQ) has developed binational inventory studies for three border areas: Ambos Nogales (1995–1997), Douglas-Agua Prieta (1999–2002), and, in recent years, Yuma-San Luis Río Colorado.

The Ambos Nogales inventory showed that the majority of the emissions came from area sources rather than point sources, with engine exhaust from vehicle traffic as a major contributor of several hazardous chemicals. PM_{10} and $PM_{2.5}$ came mainly from paved and unpaved road dust stirred into the air by vehicle traffic and were the primary sources of air pollution in Nogales, Arizona. Metal emissions such as Pb came primarily from road dust stirred into the air by vehicle traffic. Most chlorinated chemical emissions came from industrial facilities. Household chemical use contributes to hazardous chemicals emissions. A higher number of point sources are in Nogales, Sonora, due to the presence of maquiladoras. Nogales, Sonora, had higher Pb emissions from lead soldering operations in the maquiladoras, and also had higher emission levels than Nogales, Arizona, for the 25 chemicals studied.

The Douglas-Agua Prieta emissions inventory showed that PM was the main pollutant in the region, with the principal source identified as vehicular activities on unpaved and paved roads as well as wind-blown dust.

Control Strategies

Under the Mexican General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente–LGEEPA), each level of government has jurisdiction over different categories of emission sources. The LGEEPA requires the federal government to work with state and local governments to develop control strategies for municipalities with serious air quality problems. The set of measures for each area to improve air quality is called a PROAIRE, and it addresses all the pollutants considered problems in that area.

Historically, Mexico has developed PROAIRES for three municipalities in the border region: Tijuana and Mexicali in Baja California, and Ciudad Juárez in Chihuahua. The most recent PROAIRE for Ciudad Juárez (formally titled Programa de Gestión de la Calidad del Aire de Ciudad Juárez 2006–2012) establishes programs to reduce ozone, CO, and PM_{10}. Using the most recent emissions inventory, it identifies sources of the offending pollutants that could be reduced and establishes 24 "actions" to be implemented related to transportation and mobility, industry, commerce and services, health protection, environmental education, institutional strengthening, and binational coordination.

The PROAIRES for the two municipalities of Baja California were in effect from 2000 to 2005. A new PROAIRE was being developed for Mexicali in 2010. In Tijuana, there have been local efforts to encourage a new PROAIRE, and this includes all levels of government.

In 2010, the Molina Center for Energy and the Environment in La Jolla, California, initiated a project with the California Air Resources Board and the National Oceanic and Atmospheric Administration that includes the California-Mexico airshed (Molina 2009). General objectives include study of the nexus between air quality and climate change along the border. Specific objectives are: (1) to characterize air emissions from major sources in the Tijuana-San Diego air basin; (2) to determine the spatial and temporal variability of anthropogenic greenhouse gas emissions, as well as traditional air pollutants; and (3) to assess possible impact of these emissions on local and regional air quality, human health, and climate change—for example, sensitivity of ozone formation to precursor gases, and sources as well as atmospheric reactivity of aerosols, particularly soot-containing particles. The results and recommendations from the study are meant to be included in Tijuana's PROAIRE 2011–2016 (Molina Center).

In the United States, the federal Clean Air Act states that, after the EPA has designated a geographical area as being in nonattainment under a particular pollutant standard, the EPA must set a deadline for the affected state to submit a plan for control strategies that will bring the area into attainment for that pollutant by a certain date. Thus, for each of the U.S. cities or counties listed in Table 3, the relevant U.S. state has submitted a SIP to EPA for each standard that is being violated.

Federal law requires some specific control strategies. Any area in "marginal" or a higher classification of nonattainment for ozone, for instance, is required to implement a "New Source Review" program, under which the state must assure that no major new stationary source of VOCs or NO_x or major modification of an existing source results in deterioration of air quality (the term "major" is defined). This challenge is typically addressed by requiring complementary "offsets," whereby the additional permitted emissions are offset by the owner paying for even larger reductions in another source. If the ozone nonattainment is in the "moderate" classification, there are four requirements, including vehicle inspection programs and imposition of retrofit requirements in many categories of emissions sources.

Additional control strategies to be included in a particular SIP are developed in consultation with local stakeholders. As part of this process, emissions inventories are developed and modeling exercises are performed on additional control strategies that could be included in the SIP to determine what result can be expected if each option or a combination of options is implemented. The potential options are numerous with regard to mobile sources, point sources, and area sources; some are generic and some depend on particular industries that exist in the geographic area in question.

In both countries, the area-specific control strategies are selected and implemented in the larger context of the development of federal laws or regulations that are, in effect, control strategies for the whole country. For instance, both countries have developed emission standards for heavy-duty diesel engines. The U.S. regulations on this topic went into effect with new engines sold in 2007; the Mexican regulations were developed more recently and are not yet in effect.

How Are We Doing?

It is clear that much has been done since air quality problems first gained widespread political attention and initial action in the 1970s. When one considers the increases in population and in the sheer volume of pollution-generating activities since that time, one can appreciate that the challenge has been confronted and much harm has been averted.

General regulations developed at the national and state levels, such as those pertaining to vehicle emissions and efficiencies, and area-specific implementation of various control strategies, have had appreciable effects. El Paso, for instance, has gone from nonattainment to attainment for both ozone and carbon monoxide. In another example, the number of days of exceedances of the ozone standard in San Diego has been dramatically reduced. In 1980, San Diego experienced 88 exceedances of the federal one-hour standard and 165 exceedances of the federal eight-hour standard. In 2008, in contrast, there were two and 35 exceedances, respectively (CARB 2010). In addition, the banning of the use of lead as a gasoline additive in the early 1990s eliminated that toxic pollutant as a serious threat to public health.

With regard to binational collaboration, much has also been done. A later section of this paper summarizes the agreements that have been negotiated, the mechanisms that have been created, the relationships that have been built, and the actions that have been taken.

But it is equally clear that many air-related problems in the region persist, and it is likely that stricter standards in the future will exacerbate the perception of the problem. The next section of this paper examines emission trends that can be anticipated over the next 20 years and future needs for increased vigilance in addressing air quality problems.

POTENTIAL AIR QUALITY ISSUES THROUGH 2030

The previous section presented a description of the current status of air quality in the border region. What can be expected in the future? It is well known that airborne pollutants result in large part from human activities and economic growth generally has a negative impact on air quality. This is particularly relevant for the border region because of its rapid industrialization rate, changes in land use patterns, and growth of population and transportation (including international trade). But as has also been seen, environmental regulations are already playing an important role in the reduction of emissions in the region. Are current measures aimed at reducing air pollution sufficient to improve air quality while allowing growth? How will changes in the emission rates, technological advances, and even population growth affect future air quality?

Many factors affect emissions for the future, but essentially they are a function of change in the volume of activities (growth or decline) combined with changes in the emission rate for the emission sources. The data used to project activity growth depend on the sector being analyzed. For example, area and point source projections are based on regional economic models. On-road, mobile projections use "vehicle miles traveled" (VMT) data in conjunction with appropriate models. Non-road mobile source projections are also based on modeling. Future changes in activity level are not only explained through sophisticated modeling; the most common and simplistic method is through the use of extrapolations of collected historic data.

Future air quality projections or forecasting could provide stakeholders with information useful to define mitigation actions and to inform the general public. The two largest U.S. border states—California and Texas—have prepared air emission forecasts.

California has a forecast up to 2020 and Texas has a forecast to 2040, but only for on-road mobile sources. Currently, there are no emission forecasts for New Mexico, Arizona, or the six Mexican border states.

Emissions Forecasts for California in 2020

Air quality forecasts to the year 2020 based on 2008 data are detailed in *The California Almanac of Emissions and Air Quality* (Cox et al. 2009). This document contains information about current and historical air quality and emissions of criteria pollutants and toxic air contaminants in California. In addition, it presents forecasted emissions.

The purpose of this section is not to replicate the in-depth information contained in the ARB Almanac, but to extract selected data that provide a foundation for this discussion. Interested parties are advised to look at the Almanac for further clarification. In summary, this document states that despite substantial growth over the last 20 years, California has made dramatic progress in improving air quality. For example, VOCs and NO_x have been reduced by about 57% and 34%, respectively. Despite the magnitude of progress, ozone and PM remain major air quality challenges, and are forecasted to remain a problem, as shown in Table 4.

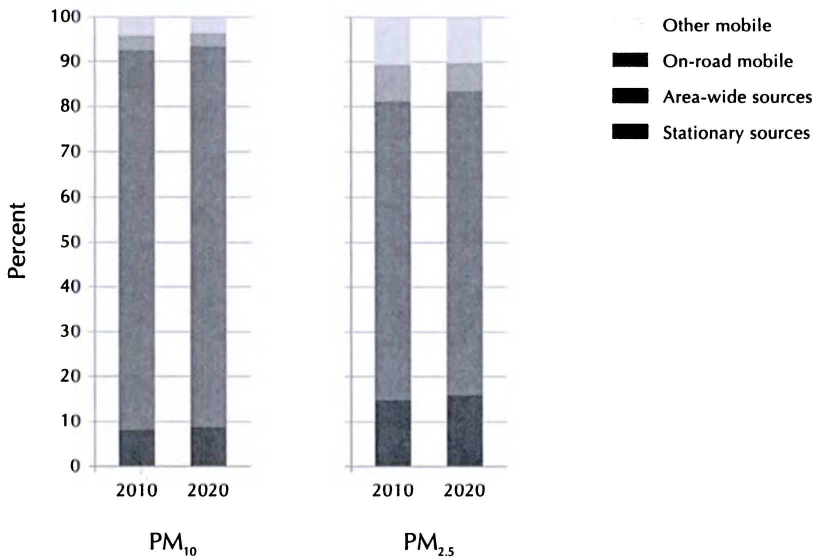
As seen in Table 4, PM_{10} and $PM_{2.5}$ emissions are forecasted to increase in California between 2010 and 2020. Furthermore, Table 4 shows that the increase for PM_{10} will amount to nearly 85% and $PM_{2.5}$ will increase 67% over the ten-year period. The main particulate source, however, continues to be area sources as shown in Figures 5 and 6.

Table 4. Estimated Average Daily Emissions in California to 2020 (in tons)

Year	ROG[1]	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Population	VMT[2]
2010	2,127	2,981	10,543	294	2,139	682	39,135,677	958,079
2020	1,950	2,173	8,369	394	2,275	707	44,135,923	1,104,522

[1] Reactive organic gas. A reactive chemical gas composed of nonmethane hydrocarbons that may contribute to the formation of smog. Also sometimes referred to as nonmethane organic gases (NMOGs).
[2] Average daily vehicle miles traveled, divided by 1,000.

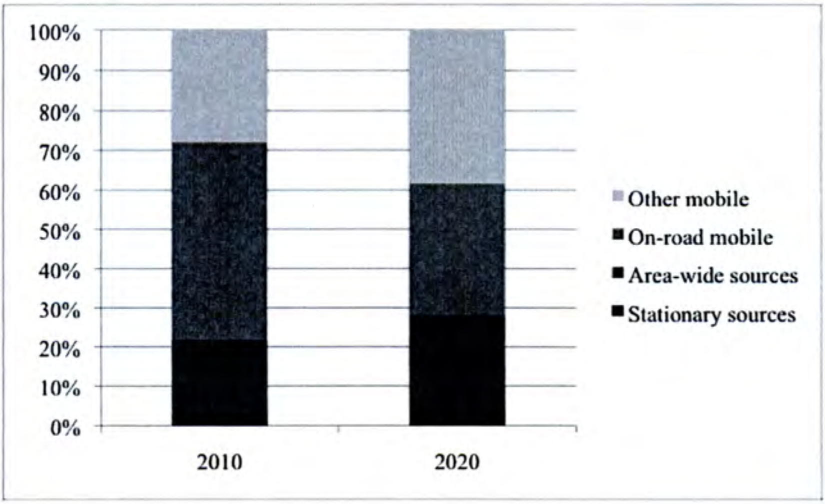
Figure 5. 2010 and 2020 Forecasted Source Contributions to PM_{10} and $PM_{2.5}$ in California



In forecasting ozone, it is important to remember that this pollutant is not emitted directly, but is formed by chemical reaction of other air pollutants. Therefore, to have a better idea of the concentrations of ozone in the future, one needs to pay attention to the principal precursors, NO_x and VOCs. Table 4 indicates that both pollutants are forecasted to decrease by 2020, which would, in turn, decrease ozone formation. However, one must keep in mind that ozone can also be transported over long distances and, thus, binational airsheds could be quite relevant (as well, perhaps, as intercontinental transport from East Asia).

Finally, Table 4 shows that CO is forecasted to become the main pollutant in California. Generation of this pollutant is likely to be dominated by on-road mobile sources, in particular gasoline vehicles, at least through 2020. CO sources are expected to shift after 2020, when non-road mobile sources will dominate as the primary category emitting CO, especially if those shift from any other fuel used currently, such as from diesel to gasoline (see Figure 6).

Figure 6. 2010 and 2020 Forecasted Source Contributions to CO Emissions in California



Emissions Estimates for Texas in 2020 and 2030

The Texas Transportation Institute (2008) prepared a study for the Texas Commission on Environmental Quality (TCEQ) that provided year-by-year estimates of total vehicle emissions through 2040, based on the expected results of existing control programs. These estimates did not take into consideration any new technologies that might emerge, any additional regulatory programs that might be promulgated after 2008, or any voluntary switch by consumers to more efficient passenger vehicles.

The Texas estimates shown in Table 5 indicate that despite increases in both population and vehicle miles traveled, the emissions of some pollutants will decrease. Other pollutants will not escalate as much as a simple extrapolation of "business as usual" combined with increases in population and VMT might lead one to expect. It should be noted that the Texas estimates are in tons per year, whereas the California estimates shown earlier are in tons per day. The purpose of both tables is to compare future years with 2010.

Table 5. Estimated Annual On-road Mobile Source Emissions in Texas, 2010–2030 (in tons per year)

Year	VOC	NO_x	CO	SO_2	CO_2	$PM_{2.5}$	Population	VMT[1]
2010	162,298	362,222	2,375,792	2,669	152,948,893	6,713	24,330,612	258,434,265
2020	96,101	113,401	1,988,061	2,679	178,947,272	4,496	28,005,788	303,161,638
2030	93,005	88,586	2,170,459	3,076	205,078,265	4,897	31,830,589	348,355,780

[1] Annual vehicle miles traveled, divided by 1,000 to save space.
Source: Authors.

The Future of Air Quality in the Border Region to 2030

Data from California and Texas could be used as partial indicators of what could happen in the entire border region with respect to air quality. In California, the San Diego-Tijuana metropolitan area accounts for nearly 40% of the overall population of the border region, with over 4.5 million people. The next largest sister-city pair is El Paso-Ciudad Juárez. In addition, two of the 10 fastest-growing metropolitan areas in the United States—Laredo and McAllen—are located in the Texas border region.

The authors do not know whether trends in the Mexican border states will run parallel to the expected trends in California and Texas. As noted earlier, the two countries are at different levels of economic development and have different levels of resources available to dedicate to environmental improvements.

Historically, one example of a lag time for a positive development pertains to emissions standards for new light-duty vehicles. In the United States, so-called Tier 1 emission standards began to be phased in; these greatly reduced emissions. Subsequently Tier 2, whose phase-in began in 2004, did likewise. These standards have already had a dramatic effect on emissions from light-duty vehicles in the United States. In Mexico, a much greater proportion of the population owns older cars, which are purchased used, many of them imported from the United States. For this reason, a greater proportion of the Mexican fleet is pre-1994, and especially pre-2004. As more recent models of used cars are imported across the border for resale, the effect on total emissions will be significant.

An earlier section of this paper alluded to the possible effect of intercontinental transport of pollution from East Asia. Monitors in California and satellite imagery have confirmed that pollution from East Asia, mostly originating from Japan and rapidly developing China, regularly reaches the continental United States. Although the atmospheric dynamics are complex and the effects still uncertain, the California Air Resources Board has stated that, “Asian pollution sources may slow future progress toward clean air in California” (CARB website).

An important factor in determining the *perception* of air quality is the possible tightening of standards in both countries in the future. In fact, it is certain that ozone standards will be made stricter in the United States in the near future. Progress in reducing average concentrations will in part be dependent upon the degree to which policymakers decide that the protection of public health requires more stringent regulations.

Meeting current and future standards and protecting public health will require redoubled efforts at all levels of government. This is not an easy challenge because of the complexity of the problem and all its social, economic, and political aspects. In addition, both nations and the border states should not limit their actions only to narrow and direct air pollution issues. They should look for more holistic approaches to air quality management that tackle issues in a broader context, which should include the sociodemographic aspects that were identified earlier in this paper.

The following section of this paper will look briefly at a phenomenon that may have a negative effect on air quality: climate change.

Possible Impacts of Climate Change on Air Quality

As mentioned, forecasting emissions can provide information useful for designing mitigation strategies. But the estimations are only as good as the parameters and assumptions being used. This task is already complicated enough, but in the past several decades there has been emerging information about the possible effects of climate change.

Why is climate change relevant to air quality? The Intergovernmental Panel on Climate Change (IPCC) believes that future climate change may cause significant air quality degradation due to rising temperatures and shifts in cloud cover that affect the formation of pollutants such as ozone—in addition to increasing emissions of pollutants from fires, dust, and loss of vegetation cover.

In 2009, the EPA released a report titled *Assessment of the Impacts of Global Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-Level Ozone.* This report focused primarily on the impact of climate change on ground-level pollutants through 2050 in order to provide a more complete understanding of the range of possible impacts of global change on air quality. This report concludes that climate change should be considered by air quality managers as they develop air pollution control strategies. It also explains that climate change has the potential to produce significant increases in ground-level ozone and its precursors, due to the fact that high temperatures affect the photochemical processes that result in ozone formation and are indicators of overall boundary layer conditions (Chock and Heuss 1985). The potential impact of climate change on PM is less well understood.

The relevance of these considerations is significant for the U.S.-Mexican border area because ozone and PM are the primary pollutants of concern in the region. In addition, future climate estimates indicate that it is possible that rainfall will decrease from 0 to 0.6 mm/day by 2080 in certain areas of the U.S.-Mexican border region (INE-SEMARNAT 2006). For the border region of the United States, climate model simulations predict a warming in the range of 1 to 3°C during the period 2010 to 2039; such projected warming is greatest in the summer in the southwest. An additional trend is that annual mean precipitation is projected to decrease in the same region. Furthermore, El Niño events are likely to enhance increments in both precipitation and severe storms in the southeast portion of the region (Field et al. 2007).

Regional research studies of climate change impact on air quality have been carried out in Tucson, Arizona (Wise 2009). Modeling showed that projected climate-based changes for ozone include monthly mean increases of 4–5 ppb in summer and autumn and a summer seasonal maximum increase of up to 11 ppb. This is particularly significant since even a 10 ppb increase in ozone is associated with an increase in daily mortality (Bell et al. 2004). Suggested climate-based monthly mean changes for PM included increases of up to 9 μg/m3 in the summer months and decreases in the winter. Decreases were projected for PM extremes.

Uncertainties are still high with respect to the exact nature of the relationship between climate change and air quality. But there are already early indications that estimated increases in temperatures could increase ozone formation. Given the risk that this pollutant presents to humans, climate change should be included in the considerations of air quality managers when developing air pollution control strategies in the border region.

Historical and Current Transboundary Cooperation

Because sister cities along the Mexican-U.S. border share their airsheds, the resolution of air quality problems calls for maximum cooperation efforts between the United States and Mexican federal governments, among the 10 border states (six in Mexico and four in the United States), and between the sister cities themselves. This presents a number of challenges because of the two different legal and political systems and different languages.

Generally, the people of the two countries have not considered the situation to be adversarial. Collaboration that began with baby steps in the 1980s has increased dramatically since that time. Most of the collaborative activities have taken place under the framework of the La Paz Agreement, signed in 1983 by the presidents of the two countries, but other binational arrangements running in parallel have also facilitated cross-border accomplishments.

La Paz Agreement

The legal framework for most cooperation between the United States and Mexico on border environmental topics is the La Paz Agreement, signed in that city in Baja California Sur in 1983. That agreement stated, among other things, that each country would identify a national coordinator and that the coordinators would hold annual meetings. The document has since been amended to provide for specific actions related to air quality.

The first annual meeting of the national coordinators established an Air Quality Working Group, and this action was later formalized in 1987 in Annex IV to the La Paz Agreement, which required the Working Group to meet on a "regular basis." Annex IV also addressed the topic of air pollution from copper smelters in the border region. That annex has been rendered moot by various economic factors that have led to the closure of such smelters, but the Working Group has continued to serve a broader purpose.

Annex V, signed in 1989, addressed the "international transport of urban air pollution" more generally. This annex described a series of actions related to monitoring, emissions inventories, and modeling that each country would undertake in designated "study areas." It also stated that the two countries would attempt to "harmonize" their air pollution control standards and their ambient air quality standards, and would report to each other on any control measures adopted for the purpose of reducing air pollution.

Only one "study area" has been officially designated by the two countries under Annex V. An appendix signed in 1996 established the Joint Advisory Committee for the Improvement of Air Quality in the area of Ciudad Juárez, Chihuahua-El Paso, Texas-Doña Ana County, New Mexico, "for the purpose of developing and presenting recommendations to the Air [Quality] Work[ing] Group." This committee has come to be called simply the JAC, and is described in more detail in a later part of this paper.

Other Enablers of Cross-Border Cooperation on Air Quality

In addition to the La Paz Agreement, other binational arrangements have provided avenues that enable cross-border cooperation on air quality issues. Perhaps the most important example is a pair of affiliated institutions, the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB), created by the United States and Mexico as a result of environmental side agreements to the North American Free Trade Agreement. These sister entities began operations in late 1994.

Working together, the BECC first certifies the feasibility of specific projects that have been proposed by communities and then the NADB (which is capitalized equally by the United States and Mexico) provides loans and/or grants, often as part of a larger financing package that includes other sources of funding.

Although initially the BECC and NADB focused their attention on projects related to drinking water supply, wastewater treatment, and waste disposal, in 2002, air quality was added to the criteria for eligibility. Since then, projects related to the paving of roads, renewable energy, and other air quality-related infrastructure have been supported.

More recently the EPA has contracted with the BECC to oversee the agency's Border 2012 annual grant program, thus bringing the NAFTA-originated process and the La Paz process together.

The Arizona-Mexico Commission has also been influential on border issues in a different way than the BECC and NADB. Created more than 50 years ago and along with its sister entity the Comisión Sonora-Arizona, the Arizona-Mexico Commission is a public-private partnership. While these have a strong emphasis on trade, investment, and tourism, the environment is one of the subjects under the purview of these organizations, and their assistance on air quality will be addressed in the subsequent section on Arizona and Sonora.

Finally, the EPA has used one additional avenue to facilitate border cooperation. That agency made a grant to the Western Governors Association in the late 1990s that enabled the latter to obtain the services of a consulting firm, expert in emissions inventories, to provide assistance to Mexico's National Institute of Ecology (INE, part of SEMARNAT) on the first comprehensive emissions inventories of Mexico's northern border cities. These inventories were first published in 2004.

Multimedia Programs Derived from La Paz and the Role of Air Quality

Under the La Paz Agreement, the two countries have developed three chronologically successive, multimedia and multiyear programs that have spelled out the structure and objectives of binational cooperation related to air quality, water quality, and land contamination. The first, called the Integrated Border Environmental Plan, was in force from 1992 to 1996. The second, Border XXI, was implemented from 1996 through 2000. The next program, initiated in 2003, is called Border 2012, which will end in 2012.

Each of these programs has had a borderwide committee dedicated to air quality serving as the Air Quality Working Group named in the La Paz Agreement. Under the current Border 2012 program, this group is called the Air Policy Forum and has been meeting twice annually.

The principal structural innovation of Border 2012 was to divide the border area geographically into four regional workgroups. The intention was to generate a more "bottom-up approach" so that it would be easier for citizens, cities, and states to participate, assess their challenges, and develop solutions. The boundaries of these regional workshops can be seen in Figure 1.

Each of Border 2012's four regional workgroups has at least one task force dedicated to air quality. The California-Baja California region has two such task forces—one focusing on the San Diego-Tijuana airshed and one focusing on the Imperial County-Mexicali airshed.

The Texas-Coahuila-Nuevo León-Tamaulipas Regional Workgroup (which serves an area known as the four-state region) has created a slightly more complete structure. Because of its relatively large geographic expanse and the number of municipalities involved, it has created three subregional geographic task forces that, in turn, have created topic-specific committees. None of the local areas in the four-state region is in violation of its respective federal air quality standards and, for this reason, two of the three task forces in the region have not bothered to create air quality committees. The Gulf Task Force (covering the Lower Rio Grande Valley from the Falcon Reservoir on the Rio Grande to the Gulf of Mexico) is the only one of the three that has an air quality committee, and it has been relatively inactive.

These regional and localized collaborative efforts are discussed in more detail in the next section.

Operationalizing International Cooperation at the Regional and Local Levels

The longest, most consistent, and most productive cross-border collaboration on air quality in a specific area along the border has taken place in the region where the boundaries of New Mexico, Chihuahua, and Texas come together, referred to as the Paso del Norte region. But other collaborative relationships have also taken root and allowed for beneficial exchanges and strategic planning in the Arizona-Sonora region and in the California-Baja California border area.

New Mexico-Chihuahua-Texas: The Joint Advisory Committee (JAC)

As noted earlier, the only "study area" formally established under Annex V of the La Paz Agreement is focused on the airshed shared by Ciudad Juárez (Chihuahua), El Paso (Texas), and Doña Ana County (New Mexico). This official binational creation of the Joint Advisory

Committee, or JAC, in 1996 was the result of initial cross-border cooperation that began earlier in the decade as the Paso del Norte Air Quality Task Force.

Under Border 2012, the Chihuahua-New Mexico-Texas Regional Workgroup uses the JAC as its de facto air quality task force. Rural air quality issues in small sister-city pairs east and west of the El Paso-Ciudad Juárez metropolitan area (Presidio-Ojinaga to the east and Columbus-Palomas to the west) have been handled by two rural task forces under the regional workgroup and then forwarded to the JAC and the workgroup. Activities related to air quality in those two rural areas have been few and simple, and will not be covered in this paper.

Throughout the 1990s and until the mid-2000s, El Paso was in nonattainment for federal standards for ozone, carbon monoxide, and particulate matter. After showing improvement, it has been redesignated as in attainment for ozone and carbon monoxide over the past five years. However, a reversal of the ozone designation of attainment is expected within the next two years as the result of a newer and stricter federal ozone standard.

The JAC is composed of 10 members from each country. It includes federal, state, and local officials from both sides, plus representatives of nongovernmental sectors, both for-profit and not-for-profit. Most participants and observers believe that its sustained level of activity over the years is primarily due to its formalized constitution, regular membership, federal co-chairs, and government funding support (the EPA provides funding to the TCEQ for a staff person to serve as the part-time administrator of the JAC).

Through the JAC, the stakeholders in this airshed have engaged in ongoing sharing of information and ideas, participated in various subcommittees, and have adopted strategic recommendations that individual members could then take back to their own organizations for follow up. Policies and programs have on numerous occasions been adopted by local, state, and federal agencies on both sides after discussion in this forum.

Due to the length of time the JAC has existed and the breadth and depth of the discussions, the experience of the JAC is considered by many observers to be a very important case study in attempts at unified airshed management across an international border. The stakeholders recognize the difficulties mentioned earlier—two sovereign countries with differing legal and political systems.

Perhaps the first time the concept of a common airshed has ever been formally and explicitly recognized was in the JAC's "One Basin Resolution," which the body passed in 2002. This resolution called for a maximized management coordination across two countries and three states with regard to: (1) a definition of the airshed's physical boundaries; (2) standardized monitoring and data dissemination; (3) standardized emissions inventories; (4) joint modeling; and (5) "harmonized" standards and control programs. None of these is easy in the international context, nor can they be accomplished quickly, but participating agencies have been making a good-faith effort to work toward those objectives.

Four specific examples of collaboration based on initial discussions held at JAC meetings will be summarized to illustrate what has been done in this region. First, the El Paso City-County Health Department donated and helped install several of the air quality monitors that are in Ciudad Juárez and then trained Ciudad Juárez municipal staff on maintenance and operation. Second, the TCEQ installed technology that allowed for radio transmission of the Ciudad Juárez data on a real-time basis to the local TCEQ office, which, in turn, uploaded the data to its statewide website of real-time monitoring data.

Third, when a new Texas law resulted in more stringent pollution control limits for an electric utility serving El Paso, Texas also passed a law allowing the utility to meet its reduction requirements by engaging in a cross-border "trade," that is, financing a reduction on the other side of the border. The utility complied by paying for conversion of brick kilns in Ciudad Juárez to a much less polluting production technology, as previously described. Fourth, the U.S.-Mexican joint institutions, BECC and NADB, have also contributed to improvement of air quality by certifying and financing a project to pave many miles of dirt roads in Ciudad Juárez.

Arizona-Sonora

Cross-border cooperation in the Arizona-Sonora region has involved several of the enabling institutions mentioned earlier. The Arizona-Mexico Commission and its sister organization the Arizona-Sonora Commission played an important role in assisting EPA and the Secretariat of Environment, Natural Resources, and Fisheries (Secretaría de Medio Ambiente, Recursos Naturales y Pesca–SEMARNAP, the predecessor to SEMARNAT) in development of a collaborative effort to study air quality in three sister-city pairs beginning in 1995. The first of the three studies, all funded by EPA, took place in Nogales, Arizona, and Nogales, Sonora, or Ambos Nogales. Four monitoring stations (one already in existence and three new ones) were used to monitor meteorological conditions and several air pollutants. Two other parts of the study developed an emissions inventory and conducted a public health risk assessment. Results were published in 1999. That same year, a similar study commenced in Douglas, Arizona, and Agua Prieta, Sonora. At the conclusion of each of these studies, operations continued at only one monitor in each city and measured only particulate matter. Both Nogales and Douglas, Arizona, are in nonattainment status under the U.S. ambient standard for particulate matter (both PM_{10} and $PM_{2.5}$) and Nogales, Sonora, is in violation of the Mexican standards.

A third similar study has been carried out in the sister cities of Yuma, Arizona, and San Luis Río Colorado, Sonora, beginning in 2003. This is the largest binational air quality study ever conducted along the U.S.-Mexican border, and is expected to be completed in 2011. Yuma is in nonattainment status for PM_{10}.

Overlapping with the chronology of these three studies, the initiation of the Border 2012 program in 2003 served to stimulate additional cross-border cooperation on air quality in this region. The Ambos Nogales Air Task Force was established under this banner and meets regularly.

Since 2004, the Ambos Nogales area has received funding from various sources to address air quality issues. In 2004, Nogales, Sonora, obtained financing from the NADB to pave a number of dirt roads and thus dramatically reduce traffic-induced dust. In 2006, the Arizona Department of Environmental Quality (ADEQ) was awarded funding under EPA's Border 2012 grant program to retrofit 42 diesel-powered school buses and 50 commercial hauling trucks in Nogales, Arizona.

In a third example, three task forces of the Arizona-Sonora Commission (air, water, and environmental health) jointly developed a project concept to reclaim waste vegetable oil and grease (which were gumming up the local wastewater treatment plant) from local restaurants and turn it into a biofuel to blend with regular diesel to produce a cleaner fuel. The idea was subsequently funded as a project in 2008.

Finally, ADEQ and its counterpart, the Sonora Commission of Ecology and Sustainable Development (Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora–CEDES), share air monitoring data.

California-Baja California

A cross-border air quality task force was established in the San Diego-Tijuana area in 1996, with formal co-chairs but no structured membership. When the Border 2012 program was launched, this task force became an official body of the California-Baja California Regional Workgroup. The San Diego-Tijuana Air Quality Task Force meets on a quarterly basis. Both cities are in violation of their respective national ambient standards for ozone.

The only other major population center in this region is the cross-border pairing of Imperial County, California, and Mexicali, Baja California, located about 120 miles east of San Diego and Tijuana. Imperial County is in nonattainment status under the U.S. eight-hour ozone standard and under the particulate matter standards (both PM_{10} and $PM_{2.5}$). Officials in this area created an air quality task force around 2000 and this task force also became part of Border 2012 after 2003. This group meets five times each year. As in San Diego and Tijuana, the task force has officially recognized co-chairs, but no structured committee membership.

As with the JAC, both of these task forces serve principally as forums for exchange of information, dialogue, and identification of possible strategies for implementation. The task forces themselves have no budgets and do not implement programs or projects. However, both task forces (and especially the task force co-chairs) play an important role in reviewing project proposals submitted under EPA's Border 2012 grant program, which is administered by the BECC.

Various combinations of agencies (federal, state, and local) cooperate in several air-related activities in the California-Baja California border region. Examples include the operation and maintenance of the northern Baja California Air Quality Monitoring Network, emissions inventories for Mexicali and Tijuana, the recovery and recycling of refrigerants, and an evaluation of truck routes that pass by elementary schools on the way to the border.

In addition to participating in task force meetings, EPA meets with the Baja California State Environmental Agency and SEMARNAT twice a year to review the progress of those projects that are jointly implemented in this region.

Observations and Recommendations

The border region is experiencing rapid economic and population growth that results in increasing environmental stress. The health effects of air pollution are serious and especially affect children, the elderly, and persons with particular conditions such as asthma. Although much has been done to address air quality problems and progress can be accurately claimed, increased and aggressive action is necessary to assure a sustainable future, especially with regard to ozone and particulate matter.

On one side of the border or the other, and in some cases both, there is a need for increased monitoring, improved characterization of pollution sources, more modeling to understand how dangerous conditions develop (including how long-range transport of some pollutants can be a factor), more sophisticated identification of mitigation strategies, and increased enforcement of the laws. Furthermore, additional research is needed on the subject of how climate change may affect regional and localized air quality.

Each of those elements of air quality management can be pursued by the individual countries and states. But because the problems exist in airsheds that are binational, the situation also requires binational solutions. Officials on both sides of the border have increasingly come to recognize this and are attempting to develop a response. This requires an enhanced binational dialog that involves federal, state, and local officials, nongovernmental organizations (NGOs), and the private sector.

This is being done to varying degrees in the different airsheds, with the Paso del Norte region being perhaps the best example. But in that region and in other geographic areas, all these efforts must be improved. Air pollution cannot be sufficiently mitigated unless policymakers recognize the existence of binational common airsheds and collaborate across the border (Van Schoik 2007). The principal recommendation of this paper, then, is to encourage more cooperative efforts at managing "unified" airsheds.

Annex V, which was incorporated into the La Paz Agreement in the mid-1990s, addressed this situation generally and created a specific "study area" in the Paso del Norte area in which more formal and intensive collaboration was promoted. The authors of this paper suggest that Mexico and the United States should develop an additional amendment to the La Paz Agreement that adds one or more "study areas" and encourages even greater transborder collaboration, including in the Paso del Norte region.

As an example, the authors propose that the La Paz amendment identifies the Mexicali-Imperial Valley as a "study area" meriting significantly increased cooperation. Such identification would encourage the consideration of several types of binational collaboration and air quality management (AQM) mechanisms, most of which would also be applicable in other geographic areas. These collaborative actions include:

1. Trading of Emission-Reduction Credits

   The "rich country-poor country" dichotomy that exists between the United States and Mexico makes the possibility of cross-border "trading" of emissions credits in the Mexicali-Imperial Valley attractive. If such trades were possible—which they are not under current law—a U.S. stakeholder with obligations to reduce emissions under U.S. law could be allowed to pay instead for that same reduction amount on the Mexican side within a common airshed. Mexicali's air pollution often comes from sources such as unpaved roads; the burning of tires, trash, and agricultural waste; and power plants that use older technology than Imperial County does. It would likely be less expensive (and therefore more economically efficient) to obtain the required reduction on the Mexican side than on the U.S. side, which means that such an investment would be the most cost-effective way to obtain the air quality and public health benefits desired.

Although markets for emission reduction credits are currently possible under certain conditions in airsheds within the United States, cross-border trades are not currently authorized. Obtaining authorization would require consideration of a number of challenging issues, such as how one jurisdiction can assure that the conditions of a trade are "enforceable" in another jurisdiction. This would possibly also require an amendment to the Clean Air Act by the U.S. Congress.

2. Clean Air Investment Fund
   The identification of all sources of air pollution, regardless of national jurisdiction, could be used to initiate a program in the Mexicali-Imperial Valley aimed at encouraging polluters on both sides of the border to provide funds for emission reductions as part of a collaborative effort. The collaboration could even include development of a collective mechanism that could also attract government funding and contributions from the philanthropic community—a Clean Air Investment Fund.
3. Cost-Benefit Analyses
   Formal recognition of a common airshed should include a concerted effort to carefully assess the financial and social costs of all options for reducing emissions. Some binational AQM strategies offer a greater benefit and return on investment than others. A cooperative effort to perform cost-benefit analyses would identify those public and private cleanups that can be implemented most cost effectively, regardless of the location.
4. International Supplemental Environmental Projects (ISEPs)
   U.S. states in the border region sometimes allow companies that are being fined for environmental violations to substitute an environmentally beneficial project in the community (not necessarily at the site of the company's facility) as an alternative to paying the fine. These are called Supplemental Environmental Projects. "Voluntary" actions that polluters can take include

pollution offsets, compensations, or mitigations. Under a more aggressive effort to address binational airsheds, states could be encouraged to allow ISEPs.

5. Diesel Emission Reduction Act (DERA)
   The EPA's National Clean Diesel Campaign provides funding in cooperation with various states and regional groups of states, as well as the private sector, to reduce emissions from diesel engines. California, for instance, is part of the West Coast Collaborative. The Mexicali-Imperial Valley has water pump, tractor, and truck engines that could be included.
6. Energy Service Companies (ESCOs)
   An energy service company, or ESCO, can audit a facility, identify the most cost-effective options for increased energy efficiency, and then implement the desired improvements through a contract that allows the savings on the facility's energy bill to be shared between the ESCO and the facility. In cases in which the facility owner is uncertain about what to do or what the payoff might be, the experience and expertise of the ESCO can create a win-win situation. Stakeholders in the Mexicali-Imperial Valley could encourage the use or creation of ESCOs.
7. Renewable Portfolio Standards (RPSs)
   All U.S. border states have identified target levels of renewable energy use (either absolute amounts or percentages of generation capacity) that electric utilities must meet by certain target dates. These are usually aggressive goals that are intended to force energy providers to diversify their energy sources to alternative sources. Some of these state programs allow for trades. With appropriate statutory or regulatory authorization, trading of RPS credits could be extended across the border within airsheds, enabling clean sources of electricity in Mexico to be capitalized, built, and brought into the grid through U.S. investment. Mexicali has a great potential for development of renewable sources of energy such as geothermal, solar, wind, biomass, and tidal.
8. Binational Air Council
   Former California State Senator Denise Ducheny has proposed creation of a council that could identify, prioritize, and implement projects and strategies that would result in emission reduc-

tions through bilateral regulations and incentives. The council would be organized to represent all sectors of the Mexicali-Imperial valleys.

9. Other New and Revised AQM Strategies
Policymakers, stakeholders, and academics can use the recognition of a binational airshed to identify perverse peculiarities in the regulatory structures at and across the international, state, and local borders.

Adding new study areas to the La Paz Agreement and simultaneously increasing the explicit expectations for these study areas implies a commitment to giving the problem of air quality in the border region the attention it requires. People in the different levels of government, in academia, and in the private sector in both countries are capable of overcoming jurisdictional issues and boldly establishing patterns of cooperation that assure a sustainable future for the citizens of this dynamic region.

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The Response of U.S.-Mexican Border Cities to Climate Change: Current Practices and Urgent Needs

Francisco Lara-Valencia, Anthony J. Brazel, Maria Elena Giner, Erika Mahoney, Rupam Raja, and Margarito Quintero-Núñez

Abstract

This chapter reports the results of a survey that explored local responses to climate change in the U.S.-Mexican border region. The survey's main goals were to assess the extent to which city planners and managers have gathered information about climate change and to compile an inventory of climate-related activities implemented by cities, counties, and municipalities in the border region in response to this information. Another goal of the survey was to evaluate the level of coordination across the region and to identify existing information and resource needs on both sides of the border. This assessment is a critical input in designing, implementing, and supporting outreach and capacity-building programs that are intended to improve local response to the impacts resulting from a changing climate. It is also an important tool to alert policymakers and institutions on both sides of the border about actions needed to develop more effective mitigation and adaptation measures within a sustainability framework.

INTRODUCTION

On April 16, 2009, President Barack Obama and President Felipe Calderón announced the U.S.-Mexico Bilateral Framework on Clean Energy and Climate Change (The White House 2009). This binational agreement emphasizes the importance of cooperation in the border region as a way to promote reductions of greenhouse gas (GHG) emissions, encourage local adaptation to the impacts of global climate change, and strengthen the reliability and efficiency of transborder energy flows. In terms of strategies, the framework highlights the importance of training, information exchange, emissions inventories, fuel reduction strategies, and the application of market mechanisms to stimulate mitigation and adaptation actions.

We believe that the outcomes of policies like these depend on how well policymakers acknowledge current practices and respond to the needs of environmental managers, planners, and other local officials who deal with uncertainties related to climate change on a daily basis. In other words, in order to enable border communities to develop appropriate responses to the challenges of climate change, we need to answer important questions, ranging from: Which jurisdictions have committed to respond to climate change? What are these jurisdictions' responses? What actors are involved in those responses? What are the driving factors for those responses? What are their institutional settings? Are the major differences in the responses dictated by the size of the urban area and/or by country? Are these responses based on cooperation across jurisdictions, both nationally and internationally? Is there a balance between mitigation and adaptation responses? Are there perceived consequences in terms of equity? Can jurisdictions' current capabilities and resources support long-term and effective climate action on both sides of the border?

This analysis attempts to address some of these critical questions by presenting an assessment of the actions being adopted by cities and municipalities along the U.S.-Mexican border to respond to climate-change challenges. The objectives of the survey are to identify and describe current mitigation and adaptation strategies, explore existing needs, and characterize the level of coordination across the border. The goal is to contribute insights on how to integrate climate policymaking and local action, which can be used by agency administrators to improve programs that to some extent cover the border region, but typically fail to recognize its particularities.

The U.S.-Mexican Border Region

The international boundary between Mexico and the U.S. delineates the shared territorial limit of both countries and extends approximately 3,100 kilometers from the Pacific Ocean to the Gulf of Mexico. This political boundary bisects a vast landscape formed by a wealth of diverse natural resources and ecosystems. Freshwater, marine, wetland, rangeland, and forest ecosystems are to be found, but mostly expansive deserts are dominant and constitute sensitive and invaluable natural features shared by Mexico and the United States along their common border. Overall, the borderlands exist in an arid climate with limited water resources.

Although this region has been occupied for centuries by human communities, only during the last 50 years have the borderlands experienced rapid population growth (Anderson and Gerber 2007). In 2005, California, Arizona, New Mexico, and Texas had a combined population of 6.8 million residents in border counties, approximately 10% of the total population of the four states. Across the border, Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas had a combined border population of 6.7 million, or nearly 37% of the Mexican border states' population. The population of the region is concentrated in large urban areas, particularly in transborder urban corridors like El Paso-Ciudad Juárez, San Diego-Tijuana, and Brownsville-Matamoros. In 2005, 93% of the residents of Mexican border municipalities lived in towns with more than 150,000 inhabitants, while on the U.S. side, large metropolitan urban agglomerations like San Diego, Tucson, and El Paso included most of the population of their respective areas. It has been estimated that by 2020, 90% of the U.S.-Mexican border population will be living in densely populated areas, which amounts to roughly 16.1 million people (Border Governors Conference 2009).

The high concentration of population in urban areas and the complex set of interactions connecting urban systems and arid environments make the border region highly vulnerable to the impacts of climate change. Recent studies indicate that northern Mexico and the U.S. southwest are likely to experience significant shifts in precipitation patterns associated with climate change, including reduced precipitation in the winter, which can exacerbate cyclical drought conditions that are characteristic of the border region. As indicated by Bales et al. (2004), winter precipitation is particularly important for the region because it is the primary method for recharge of surface water and groundwater, which are relied upon to sustain human populations and ecosystems. The region's water supplies are already highly stressed because of rapid increases in population and persistent drought, especially within the Colorado and Rio Grande/Río Bravo basins (State of California 2008). These two basins supply the water needs of more than half of the population as well as agriculture and industry in the border region and have a documented history of prolonged drought, as demonstrated by studies of the Upper Colorado River using tree ring records (Meko et al. 2007). There are also indications that climate change could lead to more severe and frequent storms, flooding, coastal erosion, and extreme cold and heat, as well as an increase of heat-related diseases like malaria and dengue fever. The combination of rapid population growth and rising densities in a region marked by fragile ecosystems and limited natural resources makes the U.S.-Mexican borderlands one of the most climate-sensitive regions in North America (State of California 2008).

As is the case in other urban centers, many of the activities taking place in the major border cities generate high levels of carbon dioxide emissions, which can be directly linked to human-induced climate variability. Direct sources of GHG emissions in these cities include energy generation, motor vehicles, industrial production, and burning of fossil fuels and biomass in households. Poor waste management—a common problem in border cities—also contributes substantial amounts of chlorofluorocarbons (CFCs) and gases such as methane to the atmosphere. In addition, the reduction of green cover resulting from urban growth and sprawl diminishes the region's ability to reabsorb CO_2.

Cities can contribute in a significant way to climate-change mitigation because of the capacity of local jurisdictions to adopt energy saving programs, stimulate the use of renewable energy sources, and implement programs that target offsetting GHG emissions (UN

Habitat 2009). Cities can also play a critical role in climate-change adaptation by enacting appropriate land-use regulations, mandating sustainable infrastructure development codes, and communicating with citizens more effectively about the urgency of adaptive behavior. However, there is great variability in the ways cities react to climate-related challenges, which raises questions about the role of information, resources, and institutions in shaping local climate action.

Local Response to Global Climate Change

The Intergovernmental Panel on Climate Change (IPCC) influenced most of the early national policies on climate-change prevention, many of which incorporate the Kyoto Protocol goal of reducing the 1990 levels of GHG emissions by 80% by 2050. As the issue of climate change gained international attention and more people became familiarized with its effects, local response and action blossomed. Local Governments for Sustainability, founded in 1990 as the International Council for Local Environmental Initiatives (ICLEI 2010), is one example. Since its inception, ICLEI has sponsored a variety of programs targeting both developed and developing countries. One program is the Cities for Climate Protection (CCP) campaign, which provides valuable tools to initiate local mitigation and adaptation actions through a milestone process involving five steps: (1) conduct a baseline emissions inventory and forecast; (2) adopt an emissions reduction target for the forecast year; (3) develop a local action plan; (4) implement policies and measures; and (5) monitor and verify results. In February 2007, CCP had 674 participants from 30 different countries (Gore and Robinson 2009).

Other international networks of municipalities working on climate change include the Clinton Climate Initiative's "C40 Cities" program to support 40 large urban centers committed to tackling climate change. An example of C40's work can be found in Mexico City, which in 2008 adopted a Climate Action Plan committing the local government to reduce GHG emissions by 12% by 2012 (Gobierno del Distrito Federal 2008). To achieve this goal, Mexico City's plan proposed 26 greenhouse gas mitigation actions including the "greening" of public buildings; use of renewable energy in public facilities; construction of waste processing centers to recycle, compost, or incinerate municipal trash; adoption of sustainable transportation practices; and public involvement. Some of the specific actions under consideration are the distribution of 10 million compact fluorescent bulbs to be used in homes, replacement of the entire municipal fleet with fuel-efficient, low-emission vehicles, and subsidies to encourage taxi drivers to replace older vehicles with more fuel efficient ones. According to its Climate Action Plan, these measures will allow the city to reduce CO_2 emissions by 400,000 tons each year.

Overall, municipal action on global climate change has primarily taken place in developed nations or metropolitan areas in the developing world. However, the Copenhagen Accord signed at the Conference of the Parties (COP) 15 Summit in December 2009 is an attempt to change this through mitigation programs adopted voluntarily by developing nations that pledged to reduce the carbon intensity of their economies (United Nations 2009). Countries such as India and Mexico have announced targeted cap-and-trade systems to lower GHG emissions in certain sectors. Such policy action might encourage more localized climate-related measures to be undertaken in those countries. The following section is an analysis of local climate action in the U.S., Mexico, and the border region and explores some of the political and institutional factors that seem to be influencing such actions.

Local Climate Action in the United States

Beginning in the 1990s and encouraged by the Kyoto Protocol, many cities in the United States began to study the potential local effects of global climate change. The impetus to respond to climate-change issues comes in various iterations through institutional, economic, social, and scientific means. Riding the wave of global awareness and the U.S. Environmental Protection Agency's (EPA) climate programs, cities began implementing actions that fall within the concept of climate-change mitigation and adaptation strategies. In many cases, these actions were integrated into the planning repertoire of cities by granting jurisdictional approval of comprehensive plans, which are referred to as climate action plans (Wheeler 2008). There was also a response related to the rising cost of oil in the U.S., which spiked in 2008, causing concern over finite oil supply and dependence on foreign oil (Newman, Beatley, and Boyer 2009).

In general, it seems that the propensity of a city to take action to protect itself against the effects of climate change is correlated with its level of vulnerability to the risks of climate variability and the receptivity of its social and civic organizations to opportunities for local action on GHG emission targets (Brody et al. 2008; Zahran et al. 2008). The Sierra Club's Cool Cities Campaign, the U.S. Green Building Council (USGBC), ICLEI, and the U.S. Conference of Mayors Climate Protection Agreement are all programs meant to provide U.S. cities with opportunities to act locally on global climate-change issues. These programs sponsor efforts that range in nature and intensity. Their actual effectiveness in reducing greenhouse gases and increasing the resiliency of urban communities in the U.S. still needs to be assessed.

For example, ICLEI (2010) sponsors a campaign to support local governments by "generating political awareness; establishing plans of action toward measurable sustainability targets; working toward meeting these targets through the implementation of projects; and evaluating local and cumulative progress toward sustainable development." Though ICLEI is now a global initiative with membership in 68 countries, almost half of its membership consists of U.S cities.[1] Among them are large border metropolitan areas like Phoenix, San Diego, and El Paso, but also smaller jurisdictions like Chandler, Arizona; Chula Vista, California; and Silver City, New Mexico.

The U.S. Conference of Mayors (2010), through its Climate Protection Agreement, is the primary municipal platform engaged in reducing GHG emissions and mitigating climate change in the U.S. The agreement specifies a group of three actions that signatory cities commit to in order to "advance the goals of the Kyoto Protocol": (1) local adoption of a set of greenhouse gas reduction targets equal to, or stricter than, the Kyoto Protocol targets; (2) work with federal and state governments to enact policies that allow the U.S. to comply with the reduction targets proposed by the Kyoto Protocol for the country;[2] and (3) promote the passing of a bipartisan legislative package to reduce greenhouse gases in the U.S.

Cities participating in initiatives such as ICLEI and the U.S. Mayors Climate Protection Agreement probably epitomize what has been referred to by Heinrichs et al. (2009) as "proactive cases." Their current strategies and actions are perhaps second-generation practices stimulated by programs created by the EPA and other federal agencies to promote the "greening" of U.S. cities. A survey of cities and counties in California indicated that jurisdictions that are members of ICLEI and the U.S. Mayors Climate Protection Agreement are much more likely to be developing inventories and action plans (Hanak et al. 2008). This study also reveals important variations in the level of efforts by municipalities and regions. According to a survey conducted by the Mayor's Conference in 2007 (U.S. Conference of Mayors 2007), the most frequently reported actions implemented by cities participating in the agreement are: (1) the utilization of more energy-efficient lighting technologies in public buildings, streetlights, parks, traffic signals, and other applications; (2) the use of renewable energy; (3) the retrofitting of public buildings into more energy efficient, healthy, and environmentally sustainable structures; (4) the promotion of green technologies among private developers and contractors; (5) the reduction of GHG emissions as part of programs to improve air quality and promote active living among residents; (6) communicating with other mayors, elected county officials, and leaders in the region to encourage them to sign on to the agreement and/or take action on climate protection; and (7) converting city fleets to alternative fuel and/or hybrid-electric technology vehicles.

Existing studies indicate that cities shape their plans to address issues that are pertinent to their regions including urban forestry, renewable energy, waste management, and transportation initiatives. However, Wheeler (2008) is critical of the progress that cities are making because many of their goals are shortsighted and inadequate, and progress is too slow. He cites problems with implementation, public involvement, and an insufficient level of understanding necessary to tackle these issues in a competent fashion. This is reaffirmed by the fact that one-third of U.S. states have not adopted a climate-change plan and a majority of municipalities have not signed a reduction agreement (Pew Center 2010).

Local Climate Action in Mexico

International campaigns like ICLEI's Cities for Climate Protection have had limited success in Mexico. As of December 2009, although only seven Mexican cities were listed as members of ICLEI, Mexico had more cities participating than any country in Latin America, except Brazil.[3] An additional indicator of the limited response of Mexican subnational governments to climate change is the fact that in 2009, only the state of Veracruz and Mexico City had completed climate action plans and, along the border, only Baja California and Nuevo León were in the process of completing their plans (INE 2010). Mexican municipalities and cities have a very low level of participation in climate-change initiatives that is due to a number of factors.

First, policymaking in Mexico is still highly centralized, with the federal government playing a primary role in setting priorities and providing the instruments and resources needed for adopting mitigation and adaptation measures. In 2007, President Calderón announced the National Strategy for Climate Change (Estrategia Nacional de Cambio Climático–ENACC), making low carbon growth a national priority and setting intermediate and long-term adaptation and mitigation targets (CICC 2007). This announcement was followed in 2009 by the unveiling of the Special Program for Climate Change (Programa Especial de Cambio Climático–PECC), which is considered part of the 2007–2012 National Development Plan. The PECC is an attempt to make the ENACC operational (CICC 2009). After careful review of these documents, it becomes clear that the Mexican government prioritizes actions from federal agencies like the National Water Commission, the Federal Electricity Commission, and PEMEX, and leaves no room for local actors.

Second, the limited information and awareness of local planners and city managers regarding climate-change threats and opportunities for action explain the low response of municipalities. Climate-related priorities in Mexico are still focused on the production of basic research to understand the potential impacts of climate variability in regions and ecosystems. Such priorities include the integration of databases to develop models for simulating possible scenarios and visualizing the impact of climate change on public health, food production, drought, flooding, extreme temperatures, and other events with huge potential implications for local communities (Basel et al. 2004). A related deterring factor is the dominant view in Mexico that sound and effective climate-related strategies will result only from the work of hard-science specialists, and the assumption that common citizens and public officials will not be moved to action by the simple act of giving them access to information produced by scientists (Romero-Lankao 2007).

Third, most local governments in Mexico are overwhelmed by the structural failures that are characteristic of urbanization in developing countries. Climate actions compete with chronic imbalances in the provision of basic public services and infrastructure such as drinking water, sanitation, transportation, open space, and safety. Mitigation and adaptation to climate change will remain as low priorities on the agenda of Mexican municipalities while more pressing concerns—such as access to clean water or safe neighborhoods—remain unresolved. The connection between these kinds of issues and climate change needs to become evident to local citizens and policymakers.

Despite these barriers, Mexican cities and municipalities are now more likely to take action on climate-change issues. In part, this is because the amount of attention given to climate change by the national media in recent years has increased significantly. Indeed, the substantial coverage of the IPCC Fourth Report and the subsequent actions taken by the United Nations and other international organizations highlighting the importance of mitigation and adaptation actions have swayed public opinion. Though many official programs are still merely declarative stances, they mark a change in attitude and willingness to act.

Methods

Given the large number of municipalities without an identified climate-change response program, and our interest in identifying current and planned actions, this research involved the collection of data from a large number of municipalities instead of in-depth data from a smaller number of municipalities or respondents. A survey was sent to department heads or senior staff in all 27 border *municipios* and

18 border counties with populations greater than 10,000 residents in 2005. A self-administered internet survey, provided in English and Spanish, was selected as the research instrument.

A total of 11 Mexican municipalities and the 18 U.S. counties completed the survey for an overall response rate of 64%. The survey targeted municipal staff—specifically, department heads or senior staff members—as respondents because of their contribution to local policymaking and the development of municipal programs. Since climate change is not an issue that falls neatly into the responsibility of one municipality or county department, individuals responsible for the following municipal functions were included: city management, public works, environmental management, urban planning, transportation, and civil protection. For smaller municipalities without multiple department heads and/or senior staff, the city clerk, mayor, or chief administrative official was selected.

The survey instrument included 40 closed-ended questions about climate change awareness, perceived scenarios, actions and actors, constraints, and collaboration. The following sections summarize the survey results within each of the topic areas explored.

Findings

Climate Change as a Matter of Local Concern

Survey participants voiced personal concerns about global change and its impacts on their communities. When asked how concerned they were about climate change, 75% of the 29 respondents said that they were concerned or very concerned. They noted that natural disasters and water shortage are two types of climate-related events that are very likely to occur worldwide and that their communities are also very likely to be affected by these types of events. They also noted that it is likely or very likely that climate change will result in increased rates of serious diseases and reductions of quality of life worldwide and in their own communities. As is common in the assessment of risk, participants perceive that the occurrence of these events is higher elsewhere than in their own communities. The gap in perceived risk between "elsewhere versus local" was the largest when asked about the likelihood of climate-related natural disasters and serious diseases, while it was the smallest when asked about water shortage and quality of life.

In order of perceived likelihood, the areas of greatest concern for the participants, due to the potential impacts on their communities were the following:

- Water shortage for urban and agricultural uses
- Extreme weather variations in characteristically cold and hot months
- Loss of habitats and species
- Severe storms and flooding
- Higher occurrence of vector-borne diseases
- Social tension and conflict

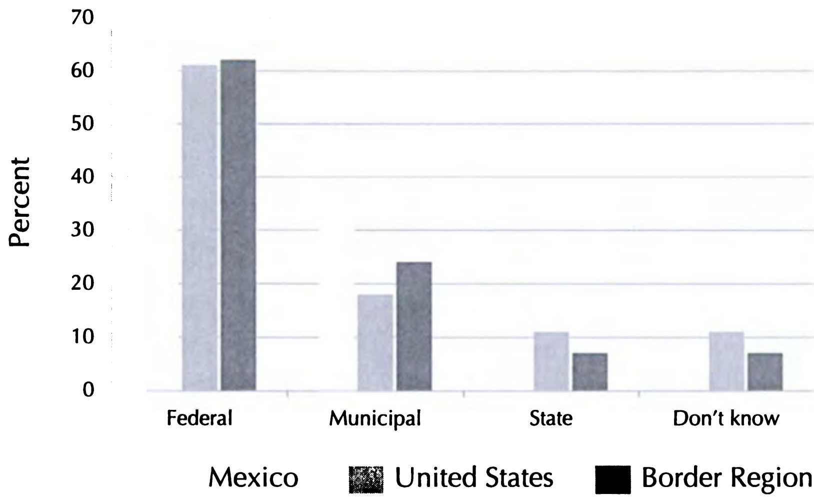
In contrast to common personally held views that reflect high concern for climate-related impacts, only 38% of the survey participants believed that their communities are concerned or very concerned about climate change.

Participants strongly agreed that climate change is a matter for the federal government, with no significant difference in opinion across the border. About 64% of Mexican respondents and 61% of U.S. respondents identified their respective federal government as the jurisdiction with primacy in dealing with mitigation and adaptation to climate change. In contrast, some difference in perception was reported regarding the role of local governments, as a larger fraction of Mexican participants (36%) identified climate change as a municipal issue, while only 17% of U.S. participants did the same. State government was only mentioned by U.S. participants (11%).

The Extent of the Response to Climate Change

Only 21% of the participants reported that their municipalities had staff working on climate-change issues. Of the jurisdictions where participants responded affirmatively to this question, the average number of personnel dedicated to climate-change-related projects is one. As is to be expected, large municipalities like San Diego, El Paso, and Tijuana were among those to reportedly have staff dedicated to such efforts, yet some mid-size jurisdictions like Cameron, Playas de Rosarito, and San Luis Río Colorado also had dedicated staff.

Figure 1. What Level of Government has Jurisdiction over Climate-Change Issues?



One of the most important initial steps a local government can take as part of an emissions reduction program is to conduct an emissions inventory. Such inventories help identify the main sources of emissions (and hence potential areas for reduction) and they are a necessary component of any program that tracks emissions over time. The survey asked whether local governments had already completed, or were planning to conduct emissions inventories. The survey revealed that very few border municipalities have conducted carbon emissions inventories. About 14%, or four of the 29 jurisdictions, reportedly have completed a carbon emissions inventory (El Paso, San Diego, Tijuana, and Nogales) and five others (Pima, Cameron, Imperial, Anáhuac, and Playas de Rosarito) had plans to conduct a carbon emissions inventory in the next 12 months.

An emissions inventory provides critical input for the development of a climate-change action plan. A climate action plan can be used to identify emission reduction targets and the policies and programs that will be employed to achieve them. These plans should also include actions the community can undertake to prepare for the impacts of climate change, including prolonged drought and higher temperatures. Only El Paso has such plans completed, yet six other jurisdictions were planning to develop such plans in the next year (Cameron, Imperial, San Diego, San Luis Río Colorado, Anáhuac, and Playas de Rosarito).

The survey also asked participants to identify whether their municipalities had already adopted or were considering adopting established programs or actions that have been proven to reduce GHG emissions. To acknowledge that such activities might be adopted primarily for reasons other than climate change, the question was formulated in the most general terms. Table 1 summarizes the number of jurisdictions on both sides of the border that were undertaking, or were planning to undertake activities in each area, ranked in order of prevalence.

Table 1. Climate-related Activities among Border Municipalities

Programs/Actions	n	%
Use of alternative fuels and/or hybrid-electronic technology to run municipal fleets	6	20.7
Purchase of alternative-fuel, hybrid-gas/electric, or all-electric vehicles	9	31.0
Promotion of public transportation: car sharing, biking, or walking to work or school	10	34.5
Promotion of transit-oriented development or mixed-use development	10	34.5
Use of more energy-efficient technologies in public buildings, streetlights, parks, etc.	12	41.4
Retrofit municipal buildings to be more energy efficient, healthy, and environmentally sustainable	16	55.2
Generation of renewable power from existing city facilities (i.e., landfills)	16	55.2
Promotion of water saving and water resources protection (i.e., water recycling)	19	65.5
Protection of open and natural spaces	19	65.5
Promotion of solid waste recycling and waste minimization	22	75.9

Waste reduction, open space protection, water conservation, and water resource protection are the most frequently employed climate-change mitigation efforts undertaken by border municipalities. In addition, a number of border municipalities have implemented measures to improve energy efficiency, including retrofitting public buildings and facilities. The emphasis on waste reduction and water conservation activities is likely a response to pressure by residents to improve systems for waste management as growing populations generate more waste and access to clean, affordable water is demanded by more residents.

Although levels of climate-change mitigation activity are similar for most border municipalities, there are some striking differences across the border. Mexican municipalities tend to be more active than their U.S. counterparts in cultivating renewable energy through existing facilities. This might be attributed to the fact that many of the Mexican municipalities possess relatively newer and larger landfills with the capability to generate power. In contrast, U.S. counties and municipalities are more active in the promotion of transit-oriented development, a planning technique barely known in Mexico.

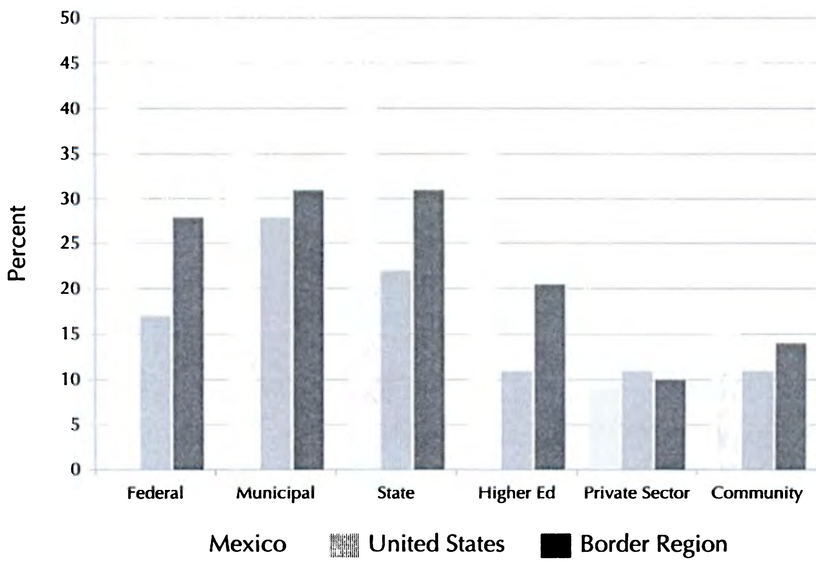
The Extent of Collaborative Action

Local governments typically partner with outside entities to conduct the inventories or undertake actions to mitigate climate-change impacts. ICLEI's Cities for Climate Change Protection has been a particularly important partner for local governments in Mexico and the United States and the U.S. Conference of Mayors conference. However, among border municipalities, only El Paso has joined this initiative; no involvement in any other partnership was reported either in Mexico or in the United States.

Mexican municipalities are more likely to work in coordination with federal and state agencies. Higher education institutions are also a common partner of Mexican municipalities because of their capacity to support in the analysis and formulation of policies and programs. U.S. cities and counties are more likely to coordinate efforts with state agencies and other municipalities. U.S. federal agencies and universities play a less important role than their Mexican counterparts. Both Mexican and U.S. jurisdictions reported collaboration with private sector entities and community-based organizations. However, Mexican municipalities are more likely to work with community organizations in climate-related actions.

When asked whether this collaboration included partners on the other side of the border, only five organizations reported a transborder exchange of information (17%). All the municipalities reporting cross-border collaboration were Mexican and their partners were mainly U.S. universities.

Figure 2. Exchange of Information and Collaboration with Other Jurisdictions or Organizations



Barriers to Local and Transborder Action

The final part of the survey asked respondents to assess the extent to which information, resources, and institutional barriers were limiting their local government's ability to develop climate-related policies and programs.

When asked whether they needed more information to develop effective climate-related policies or programs, 83% of survey respondents answered in the affirmative (Table 2), with the highest necessity reported among Mexican municipalities.

Table 2. Do You Think Your City/Municipality Needs More Information on Climate Change?

Response	Mexico	USA	Region
No	1 (9.1)	2 (11.1)	3 (10.3)
Yes	10 (90.9)	14 (77.8)	24 (82.8)
Don't know	0 (0.0)	2 (11.1)	2 (6.9)
Total	11 (100.0)	18 (100.0)	29 (100.0)

Only one-third of the municipalities had applied for federal or state grant programs and tax rebates for emission projects. The most common grants or funding programs reported by U.S. municipalities were the Energy Efficiency and Conservation Block Grant (EECBG) and the Community Distributed Renewable Energy Grant, while Mexican municipalities reported the submission of proposals to the U.S-Mexico Border 2012 Program and the Border Environment Cooperation Commission (BECC).

Participants noted that the level of support in their communities for climate-related activities tends to be low in general. About 60% of the participants indicated that residents and their associations tend to provide very low or low support for climate protection-related policies, and that such support is proportionally similar among local businesses and their associations (59%). The situation is relatively better regarding the support from elected officials, with only one-third of the respondents indicating very low and low support from local politicians.

Conclusions and Policy Recommendations

Even as some municipalities along the U.S.-Mexican border are gradually becoming more mindful of the unusual risks that climate change creates—prompting greater recognition that mitigation and adaptation measures are urgent—this study has indicated that most border communities are failing to take sufficient steps to prevent climate change from presenting even larger dangers in the future. While large U.S. border cities like San Diego and El Paso are taking action, smaller urban areas on both sides of the border are falling behind even in adopting basic commitments to protect people and property from climatic variability. National differences in the level of response are also apparent. In contrast to responses in the U.S., Mexican municipalities' responses are more likely to focus on adaptive measures rather than mitigation measures. Also, it was observed that Mexican municipalities tend to favor governmental action over market-based strategies. This means that Mexican municipalities are more likely to coordinate their efforts with state and federal agencies, collaborate with public universities, and use planning and other regulatory tools to "teach by example," rather than promote private-sector driven programs. The study also demonstrates that cross-border collaboration is rare along the border, even when many of the climate threats can only be addressed binationally.

In this context, the following recommendations for climate-change action in the U.S.-Mexican borderlands should be given priority:

1. Since adaptation and mitigation are organically related in ways that have important ramifications for effective regional action, large and small cities along the border must adopt climate-change policies that include not only defensive measures but also introduce proactive measures related to land use, transportation systems, energy systems, water systems, and built environment that will dramatically reduce GHG emissions in the borderlands.
2. The region should consider the fight against chronic urban and environmental problems of the border region as integral to combating climate change. As indicated by the survey, cities on both sides of the border can act to mitigate climate change even if they do not have formal action plans. They can, for example, audit municipal buildings and operations to find ways to save energy and money. Replacement of inefficient lighting, air conditioning equipment, and water pumps are good examples of mitigation actions. This can be complemented with policies promoting energy efficient habits to be employed by those using municipal buildings and facilities, such as turning lights and

computers off during evenings and weekends. A green products procurement program is another option that can be adopted outside of a formal climate action plan.

3. Planning and cooperation across national and institutional boundaries are critical to designing, formulating, and implementing effective borderwide climate action plans. Systematic reviews need to be conducted to identify the factors that might promote effective cross-border collaboration, as well as incentives for the formation of interinstitutional bodies capable of developing an interdisciplinary climate-change agenda for the border region. Networking, training, and research are viewed as important entry points for the development of an appropriate institutional framework for cross-border collaboration and planning.

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Endnotes

[1] As of February 2010, ICLEI's membership comprised 1,107 cities, towns, and counties and their associations in 68 countries. The U.S. contributes a total of 545 members.
[2] The target is a 7% reduction from 1990 levels by 2012.
[3] The list includes the cities of Aguascalientes, Cuautitlán-Izcalli, Mexico City, Querétaro, San Nicolás de los Garza, Ciudad Valles, and Zacatecas.

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XI

Energy for a Sustainable Border Region in 2030

Gabriela Muñoz-Meléndez, Margarito Quintero-Núñez, and Al Sweedler

Introduction

Energy is central for improving social and economic well-being and is indispensable for generating industrial and commercial wealth. However essential it may be for development, energy is only a means to an end. The end is a sustainable economy, a clean environment, high living standards, prosperity, and good health (IAEA and UNDESA 2001).

Energy has played, and will continue to play, a fundamental role in the development of the U.S.-Mexican border region. Nonetheless, the energy sector has not contributed as much as it could to the sustainable development of the border region. This is particularly true where accelerated growth has far exceeded the installed capacity to supply energy. Furthermore, some of the relevant environmental indicators, such as air and water quality, are negatively impacted by the production, distribution, and end use of the existing energy sector.

Without reliable and secure energy supplies, the region cannot develop adequately. So, unless these energy sources are environmentally appropriate and economically reasonable, sustainable development of the region will be very difficult to achieve.

Under this premise, and considering the prevailing concerns regarding climate change, the most viable option for a sustainable development of a low-carbon U.S.-Mexican region seems to be the use of the vast potential of indigenous renewable sources. The advantages of renewable energy are many: sustainability, indigenousness, ubiquity, and essentially nonpolluting and carbon free. There are disadvantages of renewable energy, however. These include variability, low density, and generally higher initial cost for conversion hardware. For different forms of renewable energy, specific disadvantages or perceived problems include visual pollution, odor from biomass, perceived avian issues with wind plants, large land requirements for solar conversion, and brine from many geothermal sources (Foster et al. 2010).

The use of renewable sources of energy in the region, though, seems to be destined to play an important role in its future development. However, there will be institutional, legal, economic, and technical barriers to be overcome in order to achieve the full benefits utilizing the region's renewable energy resources.

The objective of this paper is to reflect on the needs for the development of a sustainable energy sector in the border region to 2030. This document is divided into three parts. The first part analyzes the current dimensions of the energy sector in the border region, specifically, infrastructure, economy, and environment. The second part describes issues related to sources of renewable energy in the region. Finally, the last section draws conclusions and makes suggestions on how to overcome barriers to the development of a sustainable energy sector in the border region to 2030.

Current Energy Infrastructure

The following is a description of the current energy sector infrastructure in the border region, including cross-border energy connections.

Natural Gas

Mexico and the U.S. have 15 interconnection points with a maximum distribution capacity of 3,349 million cubic feet per day (MMcf/d) for importation to Mexico. Eight of these interconnections are not connected to the Mexican national grid of natural gas. In Tamaulipas, the Kinder Morgan, Tetco, and Tennessee gas pipelines (connected to the national grid) are bidirectional and capable of exporting a maximum gas volume of 750 MMcf/d to southern Texas. During 2007, total imports were 844 MMcf/d, while exports reached 139 MMcf/d; both exports and imports used the gas pipelines located at the border region (SENER 2008a). Regarding the use of interconnections, in 2007, for the third year in a row, the interconnections of Gulf Terra and Tetco (for imports) were not used. The Tijuana gas pipeline has not been used since 2002, as Baja California is using the Algodones gas pipeline for imports (see Table 1 and Figure 1).

Liquefied Natural Gas (LNG)

There are two operating LNG terminals in Mexico, both in the border region. One is the Altamira port, a joint venture of Royal Dutch Shell (50%), Total (25%), and Mitsui (25%). The terminal received its first LNG cargo in August 2006 and has an initial capacity of 500 MMcf/d with plans to increase to a peak capacity of 1.3 billion cubic feet per day (Bcf/d). In 2007, Altamira received 32 shipments of LNG from Egypt, Nigeria, and Trinidad and Tobago (EIA 2009; SENER 2008a).

The second is the Costa Azul terminal near Ensenada. Costa Azul is operated by Sempra and began receiving LNG in 2008. The design baseload throughput of the Costa Azul LNG terminal and plant is 1,000 MMcf/d. Sempra supplied half of its LNG throughput to Baja California at startup in 2008 and will provide its entire throughput to Baja California by 2015. The main users of the gas in Baja California are the combined cycle thermoelectric power plants. Ninety percent of the LNG throughput of the Sempra/Shell LNG terminal is sent to California. It is interesting to note that the LNG cross-border transfers are comparable in volume to land-based sources.

Table 1. Natural Gas Interconnection Installed Capacity between Mexico and the U.S.

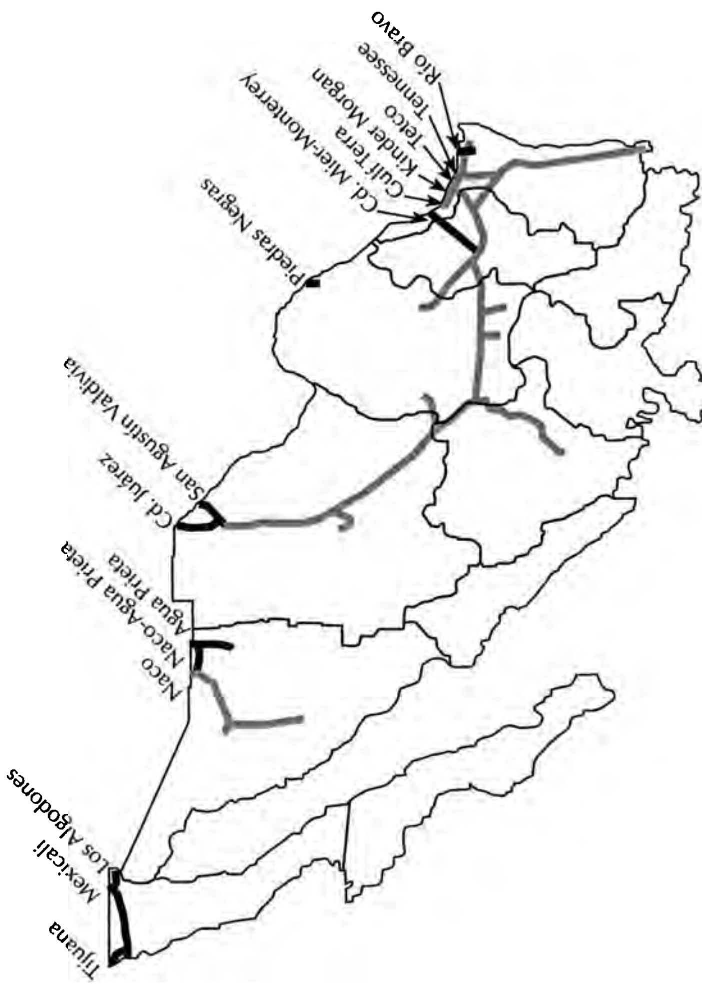
Interconnection Point in Mexico	Maximum Capacity (MMcf/d)	
	Imports	Exports
Total	3,349	750
1. Tijuana, B.C.	300	--
2. Mexicali, B.C.	29	--
3. Los Algodones, B.C.	500	--
4. Naco, Son.	130	--
5. Naco-Agua Prieta, Son.	215	--
6. Agua Prieta, Son.	85	--
7. Ciudad Juárez, Chih.	80	--
8. San Agustín Valdivia, Chih.	417	--
9. Piedras Negras, Coah.	38	--
10. Ciudad Mier, Tamps.	425	--
11. Argüelles (Gulf Terra), Tamps.	50	--
12. Argüelles (Kinder Morgan), Tamps.	300	300
13. Reynosa (Tetco), Tamps.	100	150
14. Reynosa (Tennessee), Tamps.	350	300
15. Reynosa (Río Bravo), Tamps.	330	--

Electricity

Mexico and the U.S. have nine electricity interconnections with varying capacity and voltages. Five operate for backup purposes in the event of supply distortions and system blackouts on both sides of the border. The transfer of electric energy between the U.S. and Mexico is controlled by the Mexican Electricity System (Sistema Eléctrico Mexicano–SEM) and two regional councils in the U.S.—the Western Electricity Coordinating Council (WECC) and the Electric Reliability Council of Texas (ERCO) (SENER 2008b) (see Figure 2).

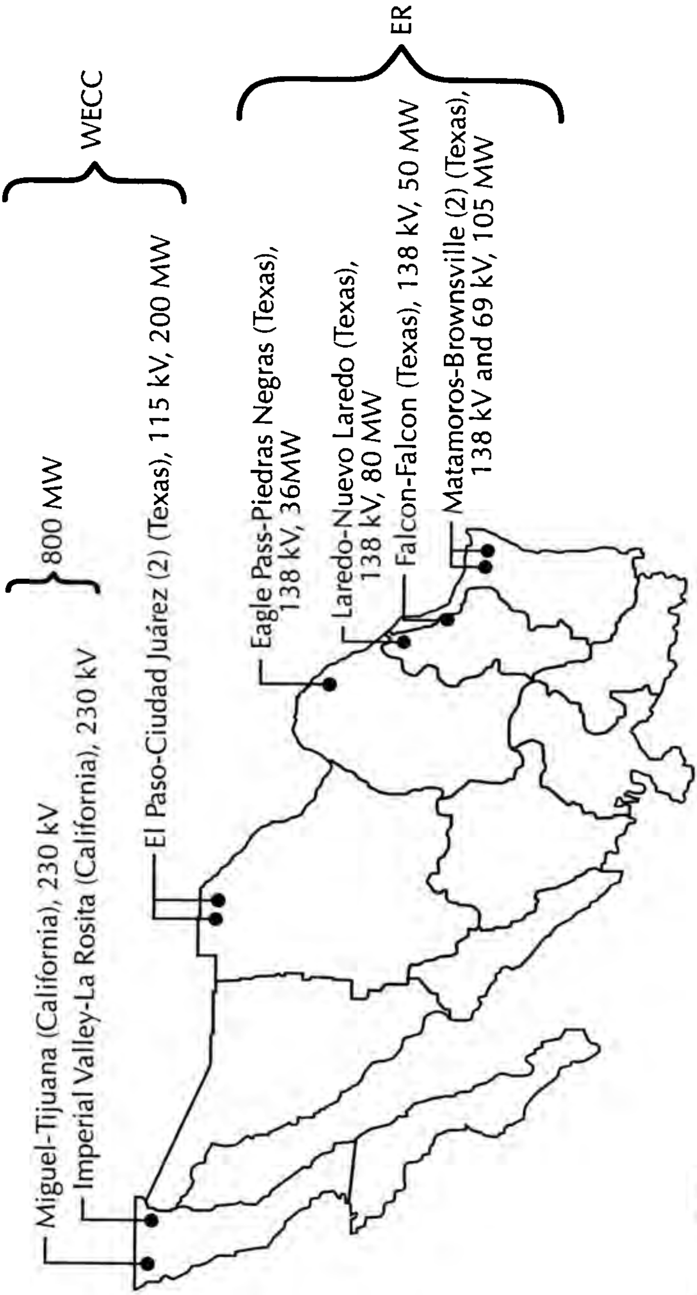
WECC operates the largest energy transfers between Mexico and the U.S. It covers nearly 1.8 million square miles (4.7 million km^2). The WECC joins SEN in Baja California through two substations:

Figure 1. Natural Gas Interconnections between Mexico and the U.S.



Source: SENER, based on data provided by CRE, IMP, PGPB, and private producers.

Figure 2. Electricity Transmission Lines in the Border Region in 2007



Source: CFE.

Miguel and Imperial Valley, each with an installed capacity of 230 kilovolts (kV). In addition, there is an interconnection at Ciudad Juárez, Chihuahua, at the Insurgentes and Rivereña substations interconnected with two U.S. substations in El Paso, Texas, and with an installed capacity of 200 megawatts (MW).

ERCO and SEN share 1,200 km along the international boundary to exchange electricity between American Electric Power Texas Central Company and American Electric Power Texas North Company on the U.S. side and Chihuahua, Coahuila, Nuevo León, and Tamaulipas in Mexico. These are backup connections, with the exception of those in Piedras Negras, Coahuila, and Eagle Pass, Texas, which are more permanent points of exchange. The total transmission capacity is 36 MW.

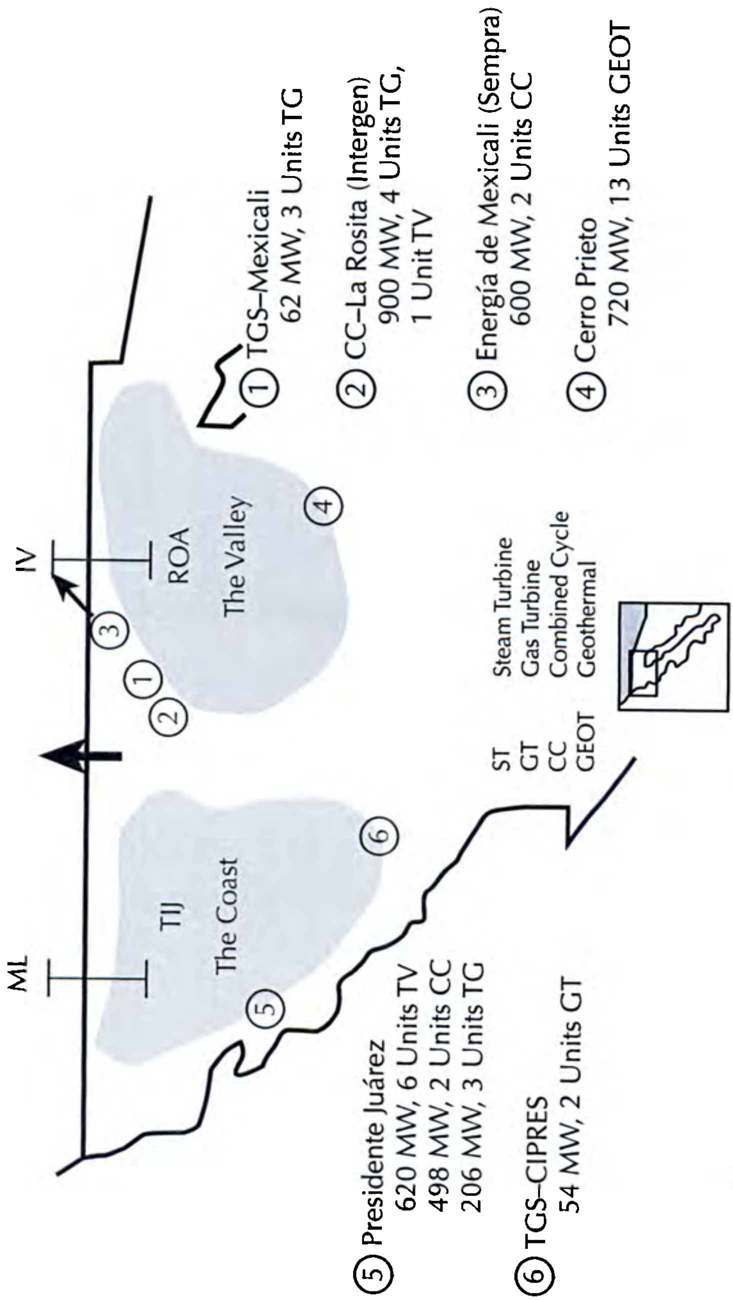
In 2007, the largest electricity exchange—83.5% of the total electricity exported between the U.S. and Mexico—took place in Baja California (SENER 2008b). Given this large exchange, the next two sections will look in further detail at power generation in Baja California and its interconnection with California.

Power Generation in Baja California

The current electricity infrastructure in Baja California (see Figure 3) consists of four power generating plants, several small plants, and an adequate system of transmission lines, concentrated in two zones, the valley and the coast. The grid is connected to San Diego using four lines of 230 kV. One of these lines is located in Tijuana, and the rest are located in Mexicali. The four transmission lines belong to the U.S. companies of Sempra, InterGen, and San Diego Gas & Electric.

The only source of indigenous energy that is utilized on a large scale is the geothermal power plant located at Cerro Prieto, south of Mexicali. It has a capacity of 720 MW and is comprised of 13 units with ages ranging from 42 to 12 years. In Baja California on the coast, there is also a natural gas-fired combined cycle plant, the Presidente Juárez central power plant, located at Playas de Rosarito. This plant produces 1,330 MW and started operations in 2001. In addition to these two power plants, there are two more combined cycle plants in Mexicali: La Rosita and Termoeléctrica de Mexicali, which have been operating since 2003. The Federal Electricity Commission (Comisión

Figure 3. Power Generation in Baja California



Source: CFE.

Federal de Electricidad–CFE) operates 10 backup units that are distributed in Tijuana and Mexicali and range from 16 to 41 years in age. Together, they all have an installed capacity of 384 MW.

As is seen from the previous description, the Baja California energy sector is very much concentrated in the valley region, which is essentially Mexicali and its surroundings. In this area, there are two privately owned gas turbine combined cycle power plants: Sempra-Termoeléctrica de Mexicali and InterGen-La Rosita. The La Rosita plant is now owned by a Canadian retirement fund. Both plants have been exporting power to California since mid-2003.

Power Transmission Lines at the California-Baja California Border

The two transmission lines connecting the Mexicali export plants to the Imperial Valley are each capable of carrying up to 1,200 MW; currently, though, the plants serving these transmission lines have a capacity of 600 MW each. However, the only outlet for this power at present is San Diego via the 500 kV transmission trunk line known as the Southwest Power Link (SWPL) that connects power plants in western Arizona (Palo Verde) with San Diego. On peak demand days the SWPL operates near its 1,300 MW carrying capacity, which limits the amount of power that can be exported from Mexico. The capacity of the SWPL will be increased over the next few years to 1,900 MW.

There are also two existing 230 kV lines running parallel to the border in Baja California. These two lines are currently somewhat limited in capacity (800 MW) and would have to be upgraded to serve as viable alternatives to the SWPL for the export plants in Baja California (U.S. Department of Energy 2004).

Analysis of the Current Infrastructure

Limited capacity and aging infrastructure are key problems facing the energy sector in the border region. These are problems that are likely to become particularly acute due to increasing energy demand from economic growth in the region.

Another problem related to energy infrastructure in the border region—and one that is not fully understood—is its resilience to climatic variations. Production and energy demand will require structural modifications under climate change conditions given that a major part of energy-related operations are vulnerable in the face of extreme hydrometeorological events, maximal and minimal temperatures, and wind intensity (INE 2006).

Currently, there are efforts to build new infrastructure and to interconnect the isolated Baja California electricity system to the Mexican national grid by 2013 (SENER 2008b). However, a more serious commitment to maintenance and modernization of energy infrastructure is necessary.

Economy and Energy in the Border Region

Patterns of energy consumption maintain a positive correlation with economic activities. The consumption of energy escalates with increases in Gross Domestic Product (GDP), although not necessarily in a one-to-one relationship. Table 2 shows the total primary energy consumption for the U.S. and Mexico for selected years between 1990 and 2007.

Table 2. Total Primary Energy Consumption in Quadrillion British Thermal Units (BTUs)

Country	1990	1995	2000	2005	2007
Mexico	5.080	5.422	6. 322	6.981	7.588
United States	84.654	91.174	98.975	100.485	101.554

Note: Total primary energy consumption reported in this table includes the consumption of petroleum, dry natural gas, coal, and net nuclear, hydroelectric, and nonhydroelectric renewable electricity. Total primary energy consumption for each country also includes net electricity imports (electricity imports minus electricity exports).
Source: U.S. Energy Information Administration.

As seen in Table 2, energy consumption was on the rise for the 1997–2007 period. Furthermore, forecasts of energy generation with respect to the rate of annual average growth for the 2008–2017 period (SENER 2008b) estimate an average annual increase of 0.9% for all of North America. The U.S. has a lower annual average growth than in previous years; this slowdown is thought to be the result of maturity in the U.S. energy markets with technology and efficiency improvements. In contrast, Mexico's energy market is expected to continue expanding and electricity infrastructure and generation will have an annual growth rate of 3.3%. More importantly, regional forecasts show that the highest rate of growth will be 4.6%, which is expected in the northeastern part of Mexico that includes the states of Coahuila, Chihuahua, Durango, Nuevo León, and Tamaulipas. This growth will be driven especially by estimated growth in Nuevo León and Tamaulipas. In addition, the northwestern region of Mexico that includes Baja California, Sonora, Sinaloa, and Baja California Sur, is also expected to grow at 3.4% annually, which is slightly higher than the national average.

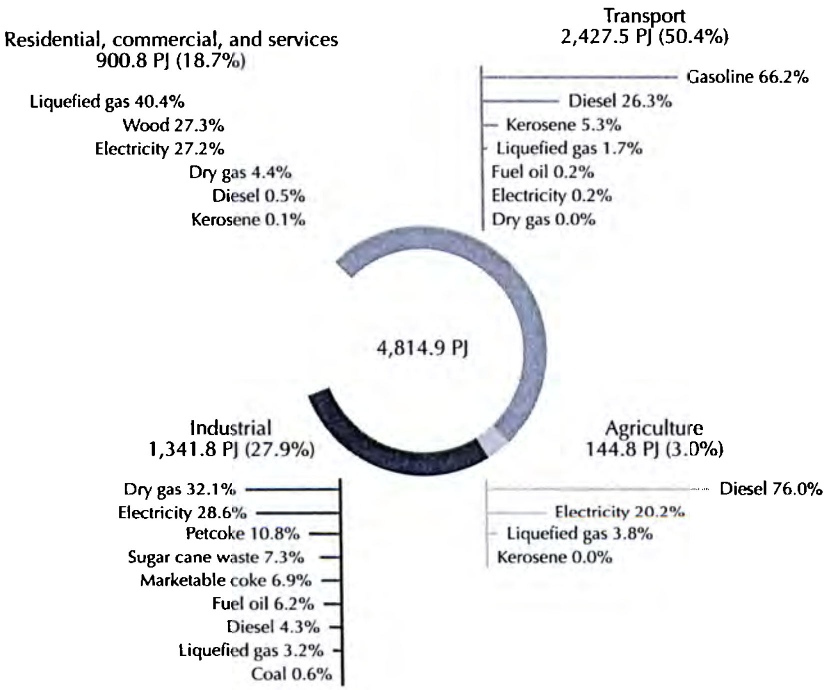
An analysis of end users of energy provides a clear picture of the sectors that emerge with the greatest demand. Energy consumption can be separated by end users such as transportation, industry, residential, commercial, and so forth. Outside the transportation sector, which at present is dominated by liquid fuels, the mix of energy use in the residential, commercial, and industrial sectors varies widely by region. This mix depends on a combination of regional factors, such as the availability of energy resources and levels of economic development, as well as political, social, and demographic factors (EIA 2009).

In its national energy balance, the Mexican Secretariat of Energy reported that, for 2008, the end users of energy were residential, commercial, and public at 18.7%; industry at 27.6%; agriculture at 3%; and transportation at 50.4%, as shown in Figure 4 (SENER 2008b). In contrast, the U.S. end users of energy at that time were residential at 22%; commercial at 19%; industry at 31%; and transportation at 28%, as shown in Figure 5 (EIA 2009).

Analysis of the Role of Energy in the Economy

The energy system of both the U.S. and Mexico is heavily based on fossil energy resources. Nearly 70% of the energy comes from combustion of fossil fuels. Coal accounts for up to 41% of the fuel mix for generating electricity, particularly in the U.S. Fossil fuel use is closely related to the generation of greenhouse gas (GHG)

Figure 4. Mexican Energy End Users per Sector and Fuel Mix



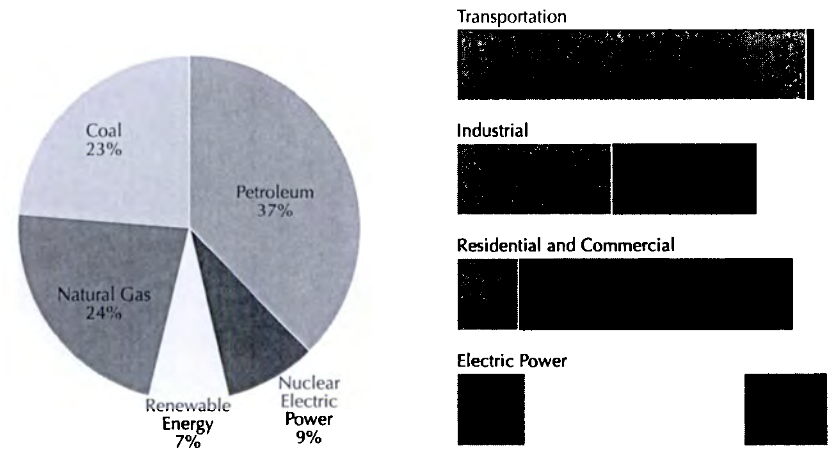
Source: SENER.

emissions. In fact, the energy sector contributes 83% of these emissions worldwide (UNFCCC 2006). The relationship between energy and GHG is further detailed in a subsequent section.

Environmental Considerations

When the entire life cycle of energy sources is taken into consideration, the environmental impacts of energy are multiple. This life cycle includes extraction (i.e., coal mining), processing (e.g., oil refining), transportation (i.e., LNG shipments), and final use (e.g., electricity generation at central power plants). Such diverse impacts may be divided into two large categories: those occurring locally and those taking place outside the region of end use. While it is beyond the

Figure 5. U.S. Primary Energy Consumption per Sector and Fuel Mix



Total U.S. Energy = 99.3 Quadrillion BTU

Source: Energy Information Administration, *Annual Energy Review 2008*, Tables 1.3, 2.1b–2.1f.

scope of this paper to discuss all environmental impacts of energy, the present section will concentrate on local impacts, in particular those at central power plants in the border region.

Two significant environmental impacts are associated with central power plants: air and water pollution. Air pollution usually originates in conventional power generation that utilizes coal, oil, and gas. This generation produces high amounts of carbon dioxide (CO_2), nitrogen oxide (NO_x), sulphur dioxide (SO_2), ozone (O_3), mercury (Hg), and fine particulates, among other compounds (Vaughan et al. 2002; Miller et al. 2002). Water pollution is a consequence of water use and consumption at power plants, particularly for the cooling systems. Water can be either used or consumed in the cooling process of a power plant, whereas water is normally consumed in other power production-related operations.

In Mexico, there are four Mexican Official Norms (Normas Oficiales Mexicanas–NOMs) that are applicable to the environmental performance of power plants. NOM-085-SEMARNAT-1994 is for air pollution; NOM-001-SEMARNAT-1996 addresses water protection; NOM-113-SEMARNAT-1998 covers environmental performance of power plants; and NOM-114-SEMARNAT-1998 is for environmental performance of transmission lines. These NOMs are very relevant to the border cities of Tijuana and Ciudad Juárez.

In the U.S., there are 14 major federal environmental laws that affect energy facilities and programs, including the Clean Air Act, the Clean Water Act, and the Pollution Prevention Act. According to the standards of the Clean Air Act, two areas along the California border with Baja California—San Diego-Tijuana and Imperial Valley-Mexicali—were most severely in violation of the U.S. O_3 standard. Imperial Valley-Mexicali has had the most severe problem with PM_{10}, followed by the El Paso-Ciudad Juárez region. The Nogales-Nogales area in Arizona-Sonora has a less severe problem with PM and no violations of the ozone standard. The Lower Rio Grande Valley has not violated any of the standards.

Although viewed separately by two sets of legal frameworks, the opening and operation of conventional power plants in the border region is regulated for their potential to affect air and water quality locally. This matter is further complicated because cross-border transport of pollutants takes place between the U.S. and Mexico, as both countries share binational airsheds and binational aquifers, surface waters, and coastal waters.

Air Quality and Central Power Plants in the Border Region

The most populated regions of the border have significant installed capacity in terms of central power plants. At the same time, the pollutants from these facilities cause problems in the regional transborder airsheds.

Baja California-California Region

Mexicali and the Imperial Valley share the same airshed, which means that atmospheric pollution crosses the international border. For example, O_3 and particulate matter generated in Mexicali travel to the other side of the border and Imperial Valley and other areas of

California when the airflow originates from the southeast. When the wind flows from the northwest to southeast, however—which is the most common pattern in the region—these two pollutants originate in the Imperial Valley and cross into Mexicali (Chow and Watson 1995). It is likely that due to emissions from Baja California, Imperial Valley is not in compliance with the U.S. National Ambient Air Quality Standards (NAAQS) for PM_{10} and NO_x (Quintero and Sweedler 2004). Thus, the siting of industries—as much as new, fixed sources of emissions in Mexicali—has the potential to negatively affect efforts by Imperial Valley to meet the air quality standards set in NAAQS. Table 3 shows the potential deterioration of air quality in the Mexicali-Imperial Valley airshed through operation of La Rosita (InterGen, 1,060 MW) and Termoeléctrica de Mexicali (Sempra, 600 MW).

Table 3. Atmospheric Emissions from La Rosita and Termoeléctrica de Mexicali Power Plants (tons/year)

Power Plant	CO	NO_x	PM_{10}
La Rosita (1,060 MW)	2,100	1,907	857
Termoeléctrica de Mexicali (600 MW)	181	187	237
Total	2,281	2,094	1,094

Chihuahua-Texas-New Mexico Region

The Paso del Norte region's airshed includes portions of three states (Texas, New Mexico, and Chihuahua) in two countries (the United States and Mexico). Topographically, the region is complex, with dominant mountain features that create a bowl that traps pollutants, especially during stagnant and inversion conditions. In the early 1990s, the Paso del Norte region was declared to be in nonattainment of U.S. and Mexican national air quality standards for three different pollutants: O_3, CO, and particulate matter (PM). With respect to NAAQS, the Paso del Norte region has made significant progress. El Paso has shed its nonattainment status for one pollutant and likely will do the same with regard to the two remaining pollutants. Ciudad Juárez' air quality is also improving (Currey and Pumfrey 2006).

The Samalayuca II Combined Cycle Gas Turbine (CCGT) plant is now generating 700 MW using dry combustion systems that limit NO_x emissions to less than 25 parts per million (ppm). Three natural gas and distillate-fired combustion turbine generators are installed at Samalayuca II, which is located 42 km south of Ciudad Juárez. It is next to an existing 320 MW plant owned by the CFE. This plant has been recently updated with 7FA series GE gas turbines that work at 50% or above efficiency. They achieve high efficiency by operating at a high combustion temperature of 1,280°C made possible by the application of advances in materials and cooling systems. The improved combined cycle system also produces lower carbon-dioxide emissions, but nitrogen oxide (NO_x) emissions tend to rise with higher efficiency. To reduce NO_x emissions, the 7FA gas turbines use precise sequencing and metering of fuel and air to burners in different locations in the combustion chamber. This ensures a leaner fuel/air mix, which is a prerequisite for minimizing NO_x combustion products that are then kept below 25 ppm. The Samalayuca II plant is designed to meet U.S. emissions regulations for the El Paso region as well as those set by Mexico's environmental agency (NRI 2010).

Water Use and Consumption in Power Plants at the Border Region

Water used or consumed at power plants in the border region carries special significance because water is a scarce commodity in the area. However, water conservation seems insufficient to avoid water pollution problems, as is shown in the cases of La Rosita and Termoeléctrica de Mexicali. Both thermoelectric power plants opted for using treated sewage water as power-plant cooling water. La Rosita Power Plant receives water from the Zaragoza Wastewater Treatment Plant to cool down the power plant. Sempra Generation built an $18 million water treatment plant to clean untreated sewage water for use as power plant cooling water (http://www.sempra.com/). During the cooling process of both power plants, however, water is consumed through evaporation in the cooling towers, creating a wet cooling tower blowdown (brine) that is discharged into the river. This is of particular importance because the New River flows north into the Salton Sea National Wildlife Refuge, and the principal problem in the Salton Sea is increasing salinity.

In Chihuahua, the Samalayuca II CCGT plant comprises three GE STAG 107FA gas-fired turbine modules, each with a heat recovery steam generator and a steam turbine. The system features an air-cooled condenser, as water supply is a problem in the region and the wells supplying the two Samalayuca plants have a restricted output. The condenser operates by passing the steam from the outlet of the steam turbine through finned tubes that are cooled by air currents. The plant consumes water at 6.3 liters per second, with a peak consumption of 60 liters per second (NRI 2010).

Energy and Climate Change at the Border Region

As mentioned previously, the energy sector in the border region relies heavily on the use of fossil fuels, which are responsible for 83% of GHG emissions. In 2007, two sectors—electricity and heat generation, and transportation—produced nearly two-thirds of the global CO_2. Generation of electricity and heat is responsible for 41% of total world CO_2 emissions as compared to 27% in 1971 (IAE 2009).

Thus, this section will focus on the relationship between climate change and the generation of electricity and heat. Table 4 shows the capacity of GHG generation by fuel, in grams of CO_2 per kWh. It must be noted that values given are more of a general guide to emissions because actual values are greatly affected by input/output efficiencies of combustion.

The total CO_2 generation of a region is the added potential of the fuel mix used. Table 5 shows the fuel mix used in the U.S. in 2008 to generate electricity. Moreover, Mexico reported that in 2007 the gross generation of electricity was 232,552 GWh, of which 45.8% was from combined cycle and gas turbine power plants using natural gas, 21.3% came from conventional thermoelectric power plants, and 11.6% from hydroelectric power plants. Coal, nuclear, and renewables provided the rest (SENER 2008b). As this fuel mix varies regionally, Table 6 details the fuel mix used in the most important power plants on the Mexican side of the border.

Table 4. Implied Emission Factors per Unit of Electricity Produced, in Grams of CO_2 per kWh of Electricity and Heat Produced in the OECD Member Countries between 2005 and 2007

Fuel	g CO_2/kWh
Anthracite	870
Coking coal	710
Other bituminous coal	840
Subbituminous coal	930
Lignite/brown coal	950
Patent fuel	860
Coke oven coke	500
BKB/peat briquettes	720–1,200
Gas works gas	400
Coke oven gas	370
Blast furnace gas	2,200
Oxygen steel furnace gas	1,900
Natural gas	380
Crude oil	640
Natural gas liquids	560
Liquefied petroleum gases	480
Kerosene	630
Gas/diesel oil	750
Residual fuel oil	650
Petroleum coke	950
Peat	570
Industrial waste	450–1,600
Municipal waste (nonrenewable)	450–1,900

Source: IEA 2009.

Table 5. Electricity Net Generation in the U.S. during 2008

Fuel		Thousand Kilowatt Hours
Fossil fuel	Coal[1]	1,976,173,298
	Petroleum[2]	42,301,486
	Natural gas	798,574,077
	Other gases[3]	3,195,712
	Total	*2,820,244,573*
Nuclear		806,181,935
Renewables sources	Conventional Hydroelectric Power[4]	239,861,737
	Biomass/wood	10,901,875
	Biomass/waste	14,872,266
	Geothermal	14,859,238
	Solar thermal and photovoltaic energy	843,054
	Wind	52,025,898
	Total	*333,364,068*
Other[5]		6,879,905
TOTAL		**3,966,670,481**

[1]Anthracite, bituminous coal, subbituminous coal, lignite, waste coal, and coal synthetic fuel.
[2]Distillate fuel oil, residual fuel oil, petroleum coke, jet fuel, kerosene, other petroleum, and waste oil.
[3]Blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.
[4]Pumped storage facility production minus energy used for pumping.
[5]Batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, miscellaneous technologies, and nonrenewable waste beginning in 2001.
Source: EIA 2008.

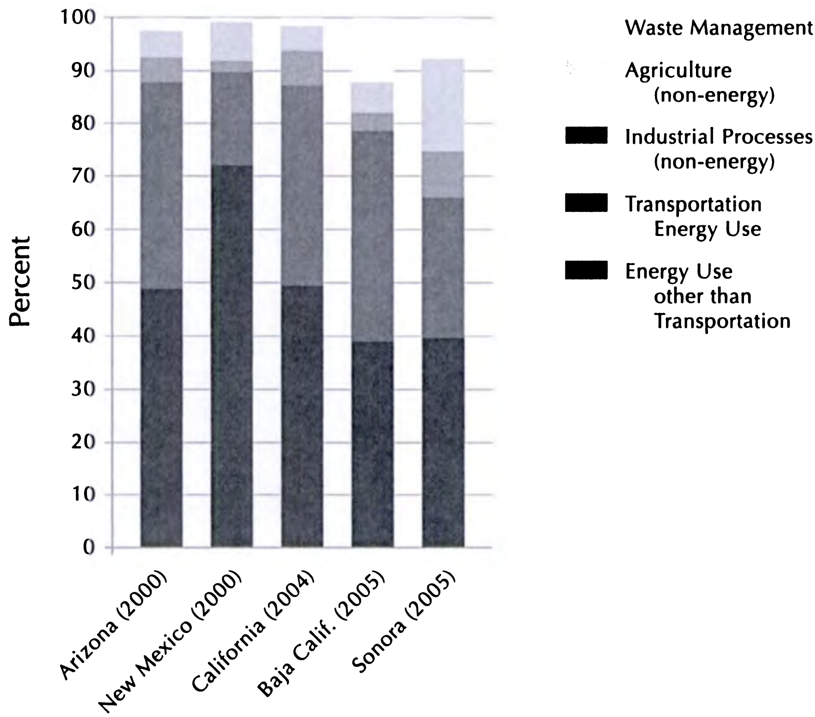
Table 6. Details of Fuel Mix and Technology Used in Most Important Power Plants on Mexican Side of the Border

State	Municipality	Power Plant	Technology Used[1]	Fuel Type[2]	Gross Capacity, GWh
Baja California	Rosarito	Presidente Juárez	TC/CC/TG	COM/GAS	3,854
	Mexicali	Cerro Prieto	GEO	n.a.	5,592
		Mexicali*	CC	GAS	2,428
Sonora	Agua Prieta	Naco Nogales*	CC	GAS	1,998
Chihuahua	Ciudad Juárez	Samalayuca	TC	COM/GAS	1,026
		Samalayuca II	CC	GAS	3,936
Coahuila	Acuña	La Amistad	HYD	n.a.	150
	Río Escondido	Río Escondido (José López Portillo)	CAR	K	9,338
	Nava	Carbón II	CAR	K	8,763
Tamaulipas	Río Bravo	Río Bravo (Emilio Portes Gil)	CC/TC	COM/GAS	428
	Valle Hermoso	Río Bravo II*	CC	GAS	2,957
		Río Bravo III*			2,063
		Río Bravo IV*			2,576

*Independent producer.
[1]TC: Conventional thermoelectric power; CC: Combined cycle; HYD: Conventional hydroelectric power; CAR: Coal power; TG: Gas turbine power; GEO: Geothermal power.
[2]COM: Fuel oil; GAS: Natural gas; K: Coal; n.a.: not applicable.
Source: CFE.

Fuel mixes used in both countries explain the main sources of GHG emissions in the border shown in Figure 6. As seen in this figure, the use of energy for electricity generation and heat contributed between 40–50%, while the contribution of energy used in transportation reached 25–40%.

Figure 6. Sectorial Comparison of GHG Emission Sources at the U.S.-Mexican Border



Source: EPA 2009.

Analysis of the Environmental Implications of Energy

As seen previously, the use of fossil fuel as main source of energy has the potential to deteriorate air quality and contribute to climate change in the border region. Another environmental problem related to energy generation is the use of water in wet cooling systems. The impact of this could be minimized by retrofitting power plants with parallel wet-dry cooling systems that could reduce water consumption by 90% or more.

In the medium term, new energy facilities need to include environmental considerations in the planning process of economic development. In this respect, Strategic Environmental Assessments (SEA) are an option that integrates the environmental with social and economic policies. A Strategic Transborder Environmental Assessment (STEA) would include assessments of both sides of the border (Quintero et al. 2009).

Future development of the energy sector's emissions intensity depends heavily on the fuels that are used in electricity generation and on the share of nonemitting energy sources such as renewables and nuclear.

The Renewable Option for a Sustainable Border Region

Renewable sources could become key elements to lay the groundwork for a transition to a more sustainable and renewable energy sector that fosters low-carbon economic growth in the border region. Fortunately, the U.S.-Mexican border region is rich in renewable energy resources as is briefly described in the following sections.

Solar Power

Solar radiation is a general term for the electromagnetic radiation emitted by the sun. On earth, solar radiation varies with the day of the year, time of day, latitude, and the state of the atmosphere. Solar radiation can be converted into useful forms of energy such as heat and electricity using a variety of thermal and photovoltaic (PV) technologies. The thermal systems are used to generate heat for hot water and for cooking, heating, drying, melting, and driving steam engines, among other uses. Photovoltaics are used to generate electricity for grid-tied or stand-alone off-grid systems (Foster et al. 2010).

There are two solar market segments: central station and distributed generation. The former involves typical power production throughout a grid. The latter refers to installations on rooftops or on land adjacent to buildings allowing homeowners, businesses, schools, and government buildings to generate their own electricity and/or heat (Summit Blue Consulting 2008).

Costs for residential solar systems are generally priced according to the system size. Costs are on the order of $12,000 for a 1 kW system to $51,000 for a 6 kW system (EVO 2009). Each kWh generated costs between $0.25 and $0.50 (Solarbuzz 2010). Most solar thermal systems cost between $2,000 and $4,500 (DOE 2003) and between $0.10 and $0.25 per kWh.

The border region has some of the best potential for solar power in the world, in particular the Baja California-California (including Zone 1 with six hours of solar insolation) and Sonora-Arizona (Zone 2 with 5.5 hours of solar insolation) regions with an average solar insolation of 5 kWh/m^2 (see Figure 7). Winter figures for daily solar gain may be from 25% to 50% less than this average.

In Mexico, solar PV electricity is widely used for lighting, communications, and appliances such as refrigerators in rural areas and small towns not connected to an electric grid. Some fishing cooperatives have also installed solar-based and hybrid solar-wind systems in isolated fishing camps (Torres and Gómez 2006).

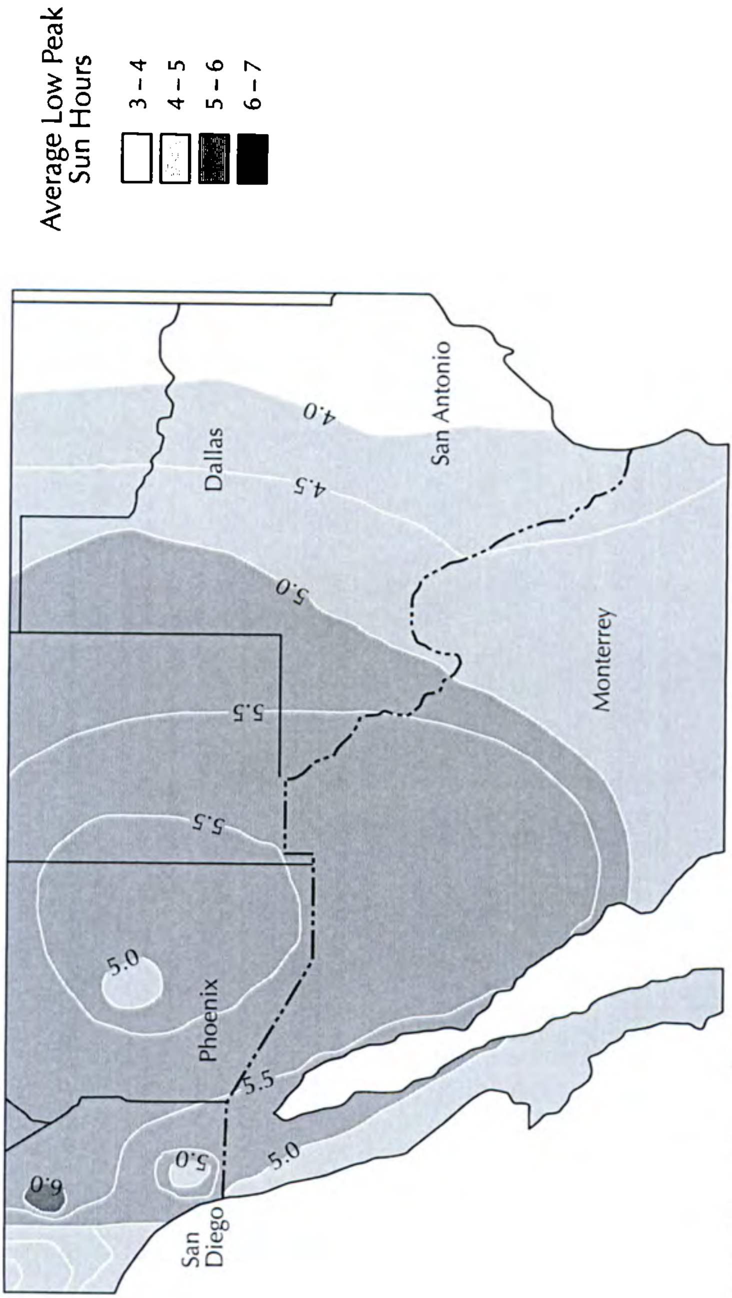
California has installed both PV and Concentrating Solar Power (CSP) with rated capacities of 528 and 354 MW, respectively. Arizona has an installed PV and CSP with rated capacities of 25 MW and 1 MW, respectively. New Mexico has 1 MW of PV rated capacity, while Texas has a PV rated capacity of 4 MW (DOE 2009).

Wind Power

Wind power refers to the capture of energy from the movement of air created by thermal differences across the surface of the earth. A wind turbine transforms the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use. Mechanical energy is most commonly used for pumping water in rural or remote locations (SDRREG 2005).

The approximate costs of wind power break down in the following manner: turbine, 76%; grid connection, 9%; and foundations, 7%. Other cost components, such as control systems and land, account for a minor share of the total costs. The total cost per kW of installed

Figure 7. Average Solar Insolation in the U.S.-Mexican Border Region

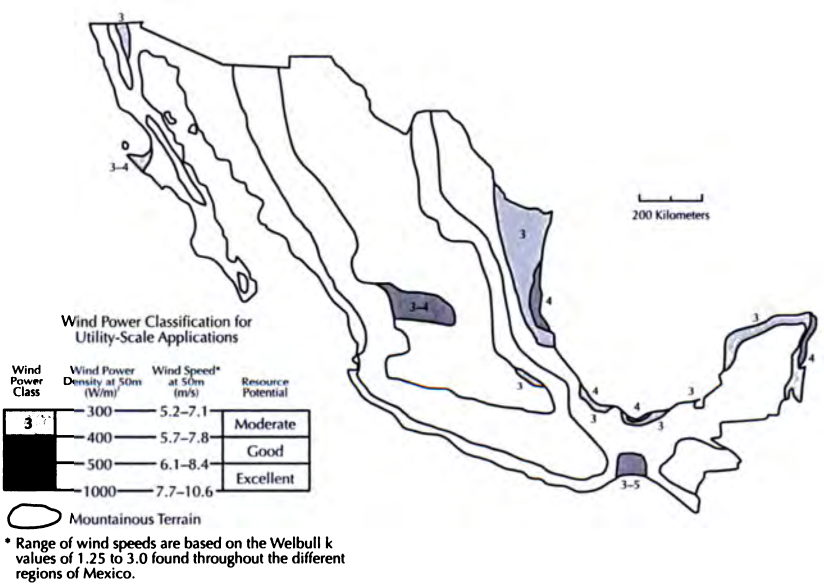


Source: Advance Energy Group.

wind power capacity differs significantly between countries, from around $1,235/kW to $1,670/kW (EWEA 2009). The average price of wind power, including the production tax credit, was about $0.04 per kWh in 2008 (DOE 2009).

In 1995, the U.S. National Renewable Energy Laboratory (NREL) carried out a preliminary wind resource assessment of Mexico using a surface meteorological data set (Schwartz and Elliot 1995). This study identified many areas of good-to-excellent wind resource potential in northern Mexico. In Baja California, the best zones are located in the La Rumorosa and San Pedro Mártir mountain ranges (274 MW). An additional area in northern Mexico with high wind potential is Tamaulipas (see Figure 8). In March 2010, the first wind farm in northern Mexico was installed in the La Rumorosa area with a capacity of 10 MW. In addition to producing electricity, this project is meant to benefit the community of Ejido Jacumé, where the first phase has been installed.

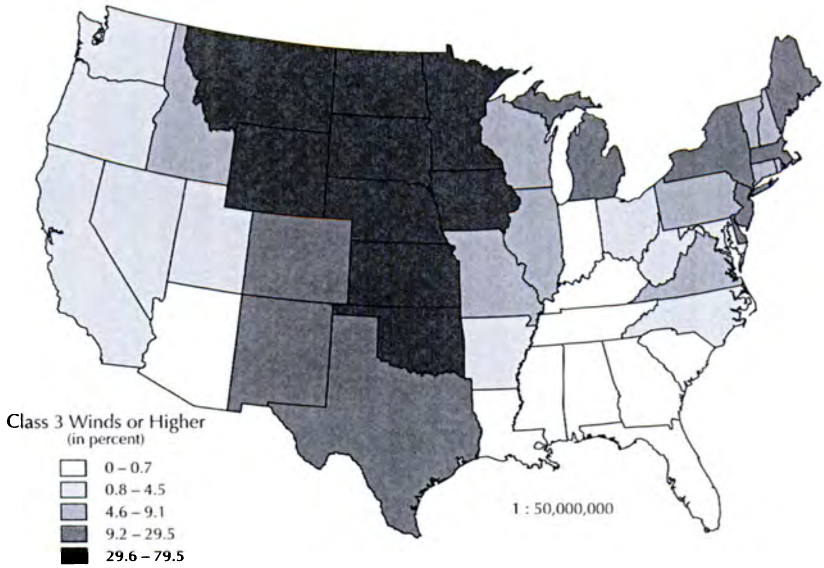
Figure 8. Annual Average Wind Resource Map of Mexico for Utility-Scale Applications



Source: NREL.

According to the Battelle Pacific Northwest Laboratory, a U.S. federal research laboratory, the highest wind potential in the U.S. is found in Texas, followed by New Mexico and California with annual energy potential of 1,210; 435; and 59 billion kWh, respectively. This wind potential calculation factors in environmental and land use exclusions for wind class of 3 and higher (see Figure 9). Texas led the United States in wind installations in 2008, with a wind installed rated capacity of 7,118 MW. California and New Mexico followed with 2,517 and 497 MW, respectively (DOE 2009).

Figure 9. Percent of Land with Class 3 Winds in the USA



Source: NREL.

Hydropower

Hydropower is electricity generated using the energy of moving water. A typical hydro plant is a system with three parts: an electric plant where the electricity is produced, a dam that can be opened or closed to control water flow, and a reservoir where water can be stored. The water behind the dam flows through an intake and pushes against blades in a turbine, causing them to turn. The turbine spins a generator to produce electricity. The amount of electricity that can be generated depends on how far the water drops and how much water moves through the system. While the types of facilities used for hydropower are often large scale, small-scale hydropower infrastructure is often more appropriate for semiarid areas such as the U.S.-Mexican border region.

The definition of "small scale" hydropower varies from country to country and state to state. A value of up to 10 MW total capacity is becoming the generally accepted definition of small scale. The principal requirements for a small hydropower plant are a suitable rainfall catchment area; a hydraulic head; a means of transporting water from the intake to the turbine such as a pipe or millrace; a turbine house containing the power generation equipment and valve gear needed to regulate the water supply; a tailrace to return the water to its natural course; and an electrical connection to the load to be supplied. The typical installed cost of a low impact power plant from 100 kW–30 MW is between $1,700 and $5,000/kW, depending on site conditions and permitting/licensing requirements. The cost ranges between $0.08 and $0.09 per kWh, which is expected to drop by about one cent by 2013 (SDRREG 2005).

The Imperial Irrigation District (IID) has seven micro hydroelectric power plants distributed along the All-American Canal, which were built at the beginning of the Imperial Valley irrigation system's operations. These plants have a total capacity for hydrogenation of 84.665 MW.

On the Mexican side, there are plans to build a 20-MW capacity micro hydroelectric power plant near the Carrizo Dam at Tecate, Baja California. This plant is expected to abate approximately 52,153 tons of CO_2 based on conventional generation by using a Voith Siemens Pelton turbine powered by 4.9 m^3/sec of water from the Colorado River-Tijuana Aqueduct, which drops 550 meters from the top of the hill. The site where this facility will be located belongs to the state of Baja California and Tecate's State Public Services Commission (Comisión Estatal de Servicios Públicos de Tecate–CESPTE). The environmental impact assessment has been finished.

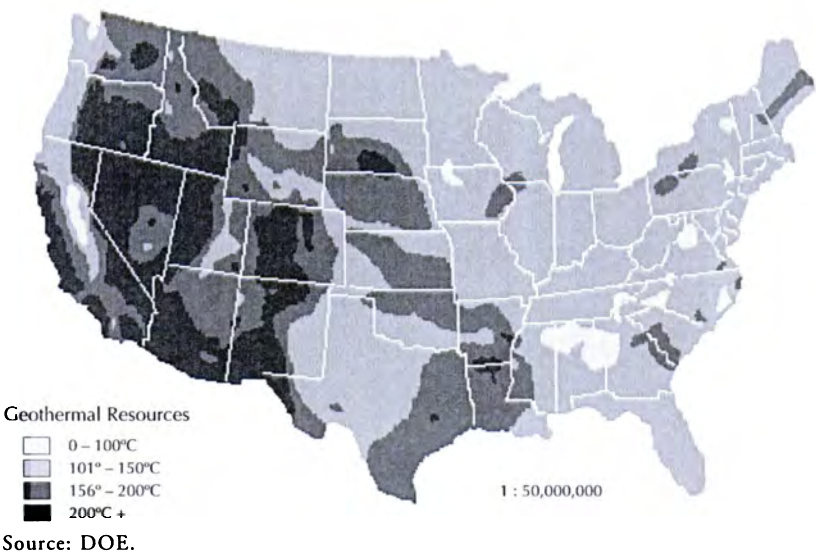
Geothermal Energy

Geothermal energy on earth originates from two sources: (1) heat that flows upward and outward across the entire surface of the world; and (2) localized heat resulting from the movement of magma into the earth's crust. The second source is the easiest to exploit.

A geothermal resource for power production comprises three major elements: heat, enough reservoir permeability, and water. A geothermal resource will be economically viable for power generation only if the four elements of economic access are met: wellhead energy cost, electricity transmission, a market for the electric power, and the power plant cost (Kitz 2007). The investment costs for geothermal plants in Mexico are approximately $1,400/kW, while the average generation cost is $0.03986 per kWh. In the U.S., geothermal energy generates power for between $0.05 and $0.10/kilowatt-hour (DOE 2009).

In the border region, geothermal resources are among the best in the world (see Figure 10) and have been widely exploited on both sides of the border.

Figure 10. Map of Geothermal Resources in the U.S.



Source: DOE.

California is one of few U.S. states with significant geothermal installed nameplate capacity, which was 2,605 MW in 2008 (DOE 2009). Imperial County, located directly east of San Diego County, has a large geothermal resource composed of hot brine near the Salton Sea. Brine is water containing high concentrations of dissolved salts and minerals and is highly corrosive to pipes and other power plant equipment. The Salton Sea geothermal site uses flash-type power plants to produce steam from the brine; the steam is used to turn the turbine generators. Activities to produce commercial geothermal power have been ongoing for decades in Imperial County. Approximately 537 MW (gross power) of capacity is currently installed there.

Mexico ranks third in the world for geothermal energy generation and has considerable installed capacity in Mexicali. This system is a hot-water (280–360°C) geothermal system at Cerro Prieto. Power plants installed by 1996 at this site had a nameplate capacity of 620 MW. In 2000, four additional 25 MW power plants were installed, bringing the total nameplate capacity to 720 MW. In 2002, Cerro Prieto produced 4,934 GWh of electricity, down from 5,013 GWh in 2001.

Biomass Energy

Transformation of waste materials into energy can generally be accomplished through biological, thermal, and chemical processes. The energy produced from these processes can be in the form of heat, gas, or liquid fuel (Kayhanian et al. 2007). A small modular combustion unit with a waste heat boiler and a capacity of less than 250 metric tons per day (TPD) costs $68,000. A small refractory wall furnace with waste heat boiler and dry scrubbers of between 200 and 500 TPD capacity costs $90,000 and $70,000 per ton of daily MSW processing capability. A small, field-erected, water wall cogeneration or electric generation facility with dry scrubbers of between 500 and 1,500 TPD capacity costs $112,000 and $85,000 per ton of daily MSW processing capability. A large, field-erected, water wall cogeneration or electric generation facility with a dry scrubber between 2,000 and 3,000 TPD capacity costs $129,000 and $112,000 per ton of daily MSW processing capacity (Velzy and Grillo 2006).

The Nuevo León Bioenergy Project in Monterrey, Nuevo León, is the first in Mexico that uses landfill biogas for electricity generation. It is a successful example of bioenergy production from MSW. This project has a capacity of 7 MW. It was developed by partial support from the Global Environment Fund (GEF) through the World Bank. Regulatory and legal changes developing in Mexico will allow the replication of this project in other landfills throughout the country (Torres and Gómez 2008).

All four U.S. border states have biomass installed nameplate capacity; California is leading with 1,217 MW, followed by Texas with 295, Arizona with 40, and New Mexico with 7 MW (DOE 2009). In California, there are independent producers of energy in the Imperial Valley, with two plants that burn agricultural waste or biomass. The first is the Imperial Valley Resource Recovery Company (IVRRC); it has a capacity of 14 MW. The second is Colmac, with a capacity of 50 MW. The plant is located in Mecca, which is in the Coachella Valley and immediately north of the Imperial Valley. Colmac primarily burns wood waste from the greater Los Angeles area.

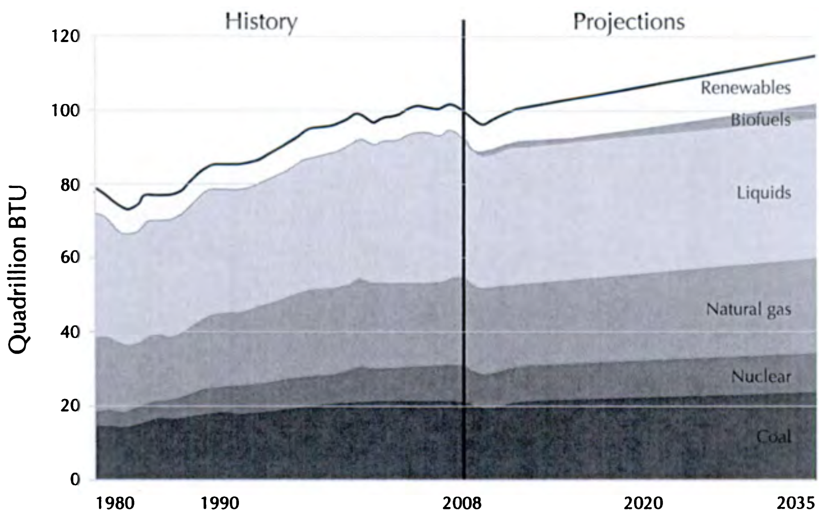
Prospective Scenario of Renewable Sources by 2030 in the U.S.-Mexican Border Region: Drivers and Barriers

In its Annual Energy Outlook 2010, the U.S. Energy Information Administration (EIA) presents long-term projections of energy supply, demand, and prices through 2035 based on results from its National Energy Modeling System (NEMS) (EIA 2010). Key results highlighted in AEO2010 include moderate growth in energy consumption, increased use of renewables, declining reliance on imported liquid fuels, strong growth in shale gas production, and projected slow growth in energy-related carbon dioxide (CO_2). Assuming that current laws and regulations remain unchanged throughout the projections, the AEO2010 Reference case provides the basis for examination and discussion of energy market trends and the direction they may take in the future.

The growth in consumption of renewable fuels is primarily a result of federal and state programs—including the federal renewable fuels standard (RFS), various state renewable portfolio standard (RPS) programs, and funds from the American Recovery and Reinvestment

Act (ARRA) of 2009—together with rising fossil fuel prices. Although fossil fuels will continue to provide most of the energy consumed in the United States over the next 25 years, their share of overall energy use is projected to fall from 84% in 2008 to 78% in 2035 (see Figure 11). The role of renewables could grow if current policies that support renewable fuels are extended.

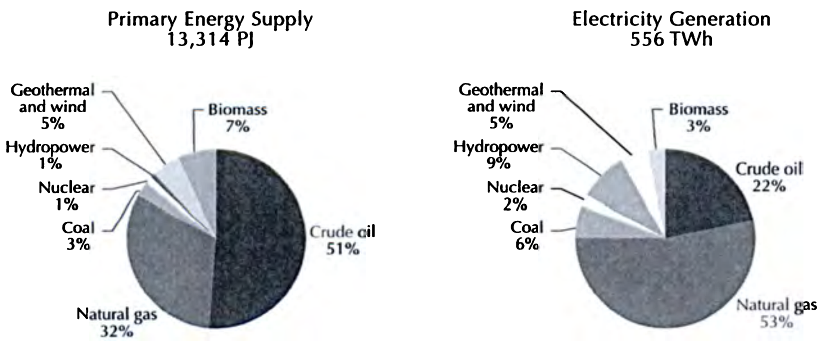
Figure 11. U.S. Primary Energy Consumption, 1980-2035 (quadrillion BTU)



Source: EIA 2010.

The first Mexican renewable energy outlook—developed at the request of SENER—anticipates that primary energy supply will double between 2002 and 2030 (Torres and Gómez 2006). Projections show that natural gas will grow at an annual rate of 3.5%. By 2030, the demand for oil is estimated at 3.4 millions of barrels per day. For renewables, hydropower will grow 2.3% per year, biomass and waste will grow by 3.7% annually, and other sources will increase each year by 4.1%. Renewables not used for electric generation will only reach 5% of the total portfolio. Biomass and waste will reduce their participation from 8% to 4% between 2002 and 2030 due to the fact that the main use of biomass in Mexico in 2004 is in the residential sector (wood for cooking). Even though there will be a reduction in total biomass consumption, the advantage will be that wood will not be used as much as agricultural and urban residues. Biomass is expected to be as important as geothermal (36% and 38% of total renewables excluding hydropower) and to be double that of wind contribution (19%). Hydropower generation of electricity is expected to double between 2002 and 2030. These findings are depicted in Figure 12.

Figure 12. Prospective Use of Renewable Sources of Energy in Mexico by 2030



Source: CMM 2005, prepared with data from "Una visión al 2030 de la utilización de las energías renovables en México," UAM 2005, México.

Although none of these studies are specific to the border region, they do provide a general framework of analysis. Thus, considering these findings and taking into account the information detailed in earlier sections of this paper, some observations can be advanced about the border region with regard to energy and use of renewable sources of energy for 2030.

1. Fossil fuels will continue to provide most of the energy consumed in the border region; coal and natural gas will play an important role. Natural gas use will increase significantly in Mexico.
2. Renewables on the U.S. side of the border will continue to increase within the overall fuel mix, particularly in California and Texas. California will increase capacity of its very diversified portfolio of sources and Texas will take the lead on installed

capacity in wind power; this is likely to happen given the current legislation and financial incentives at both the state and federal levels.

3. Renewables on the Mexican side of the border will not significantly increase their contribution to the overall fuel mix. This is likely because energy planning in Mexico is based on methodologies that only evaluate the short-term economic cost of energy generation. These methodologies rely heavily on Mexico's significant fossil fuel resources. Two components are fundamental to overcoming this: (1) legal and regulatory changes that allow greater private participation in electricity transmission, transformation, and delivery to the respective beneficiaries; and (2) economic and fiscal incentives as well as methodologies to assess the contribution of renewables to the national grid. The recent Law for the Use of Renewable Energy Sources (Ley para el Aprovechamiento de las Fuentes Renovables de Energía–LAFRE) could contribute to renewables development in the border region.

Comments and Recommendations

Energy poses a formidable challenge to those working to achieve sustainable development goals. Energy is needed to alleviate poverty, promote economic growth, and foster social development. But as more energy is consumed, stress is placed on the environment at the local, regional, and transboundary levels. While there are no absolute answers and solutions vary by region, by country, and even by locality, a common thread in reaching solutions is being able to ask and answer the right questions. Based on an analysis of existing information and forecasts, some conclusions and recommendations are given for the border region regarding energy and use of renewable sources of energy for 2030.

The total primary energy consumption in the border region will increase on both sides of the border, with faster growth in Mexico. Furthermore, the fuel mix for both countries will be based very much on fossil fuels; it is expected that natural gas will increase its importance in the border fuel mix, particularly in Mexico. It is therefore urgent to concentrate on modernizing the current energy infrastructure and implementing a massive energy efficiency program.

Performance of existing power plants and openings of new installations should be better controlled for their potential environmental impacts, particularly on the air and water. For this measure to be effective, a binational environmental management mechanism with broad public participation and a solid variety of instruments, strategies, and joint actions will be necessary.

The use of renewable energy sources contributes to the sustainability of the border region and, because of this, their use should be encouraged. The U.S. side of the border is taking firm steps to this end, but still there is room for improvement given the vast array of renewable resources available locally. Mexico should be encouraged to enter the renewable market through financial and regulatory measures. However, any renewable energy implementation should be complemented by a significant increase in energy efficiency, diversification of energy sources, and a combination of wide-area power generation and decentralized power generation, or a "SuperSmart grid."

By 2030, the use of renewables in the border region will be modest, still in an introductory stage, but already contributing to the sustainable development of the region. Additional coordinated efforts are needed on both sides of the border for the renewables market to mature and thus set the foundations of a low-carbon U.S.-Mexican border region.

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XII

Disasters Associated with Climatic Phenomena on the U.S.-Mexican Border

Juan Manuel Rodríguez Esteves

Abstract

The U.S.-Mexican border region has a semiarid climate with average precipitation ranging from 50 to 600 mm annually and temperatures that can reach 50°C (122°F). In spite of the low water availability and high temperatures, the region also has extreme weather-event scenarios. For example, Hurricane Dolly in July 2008 affected border cities of northern Mexico such as Matamoros and Ciudad Juárez, causing flooding and damage to urban infrastructure. The storm produced accumulated rainfall of up to 250 mm in a period of less than 24 hours. The city of Tijuana, Baja California, was affected by heavy rain in the winters of 1982–1983, 1992–1993, and 1997–1998. These rains were associated with the El Niño Southern Oscillation (ENSO) weather phenomenon. Flooding occurred in much of the city and caused damage to infrastructure, roads, and electricity as well as loss of life; 40 people were killed during the 1993 rains alone. This loss of life is associated with, among other things, increasing social vulnerability of human settlements at the border.

This paper aims to demonstrate that the manifestation of disasters associated with climate risk is not only due to the lack of urban infrastructure, systems, and construction materials, but also to settlements in high-risk areas and the absence of urban policies to decrease

the risk. The study of the risks of disaster should be addressed from a multidimensional perspective in order to understand the causes of risk and the relationship between threat and vulnerability. We analyze the urban evolution of Tijuana, the growth of the larger metropolitan area, the area's pluvial history, and perceptions of the inhabitants of areas considered to be at high risk with respect to climatic phenomena.

Current Problems

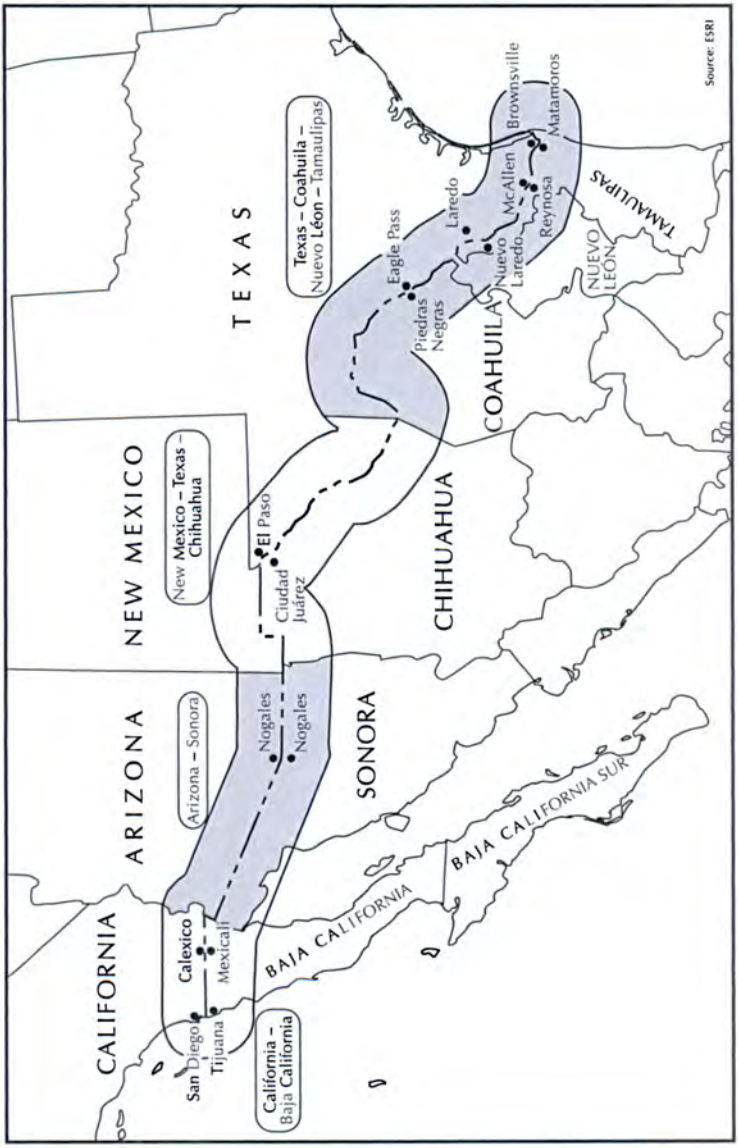
The border between Mexico and the United States extends for 3,150 km in length, spanning an area from the Pacific Ocean to the Gulf of Mexico (see Figure 1). Six Mexican states border the U.S. (Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas). On the United States side, there are four border states (California, Arizona, New Mexico, and Texas).

The U.S.-Mexican border region has great climate diversity. It includes the very dry and warm climate in the west such as that of Baja California and Sonora. Mediterranean-type climates, with rainfall in winter, are found on the Pacific coast, especially in the northern region of Baja California. Chihuahua, Coahuila, New Mexico, and Texas have dry temperate climate types. Finally, toward the east of the region, the climate type is semiwarm to temperate and is influenced by hurricane activity in the Gulf of Mexico (COLEF-SEDESOL 2004).

Water resources in the region are captured in spatial units referred to as watersheds, which transport the rainwater from mountainous regions toward the lower areas including valleys and oceans. As is shown in Figure 2, the watersheds traverse the international boundary and are shared by both nations. This is a key factor with respect to the management of the risk of disaster, since just one climatic phenomenon such as intense rain or flooding can affect both nations differently.

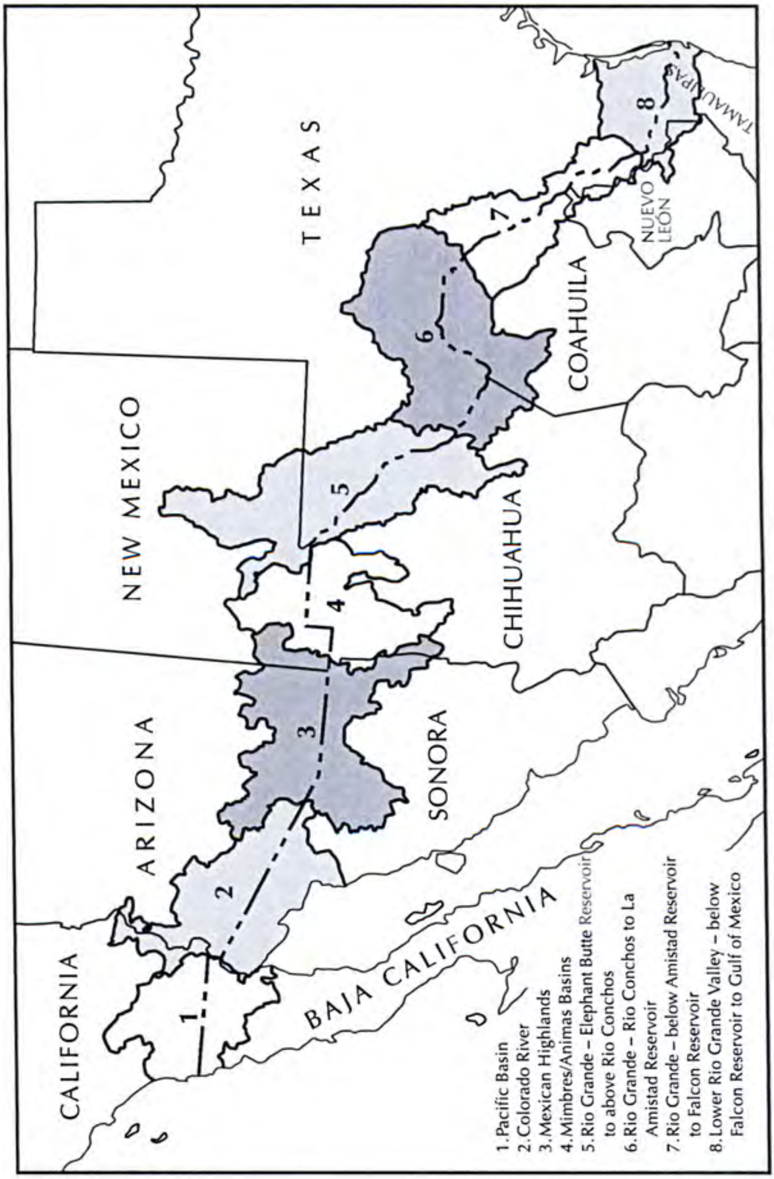
With respect to demographic growth, in 2003 the U.S.-Mexican border region had over 12 million residents located primarily in the urban systems of Tijuana-San Diego, Ciudad Juárez-El Paso, and Matamoros-Brownsville. By 2020, the region is expected to have approximately 20 million residents (SEMARNAT-EPA 2003).

Figure 1. Mexico-United States Border Region



Source: Border 2012 Program.

Figure 2. Binational Watersheds



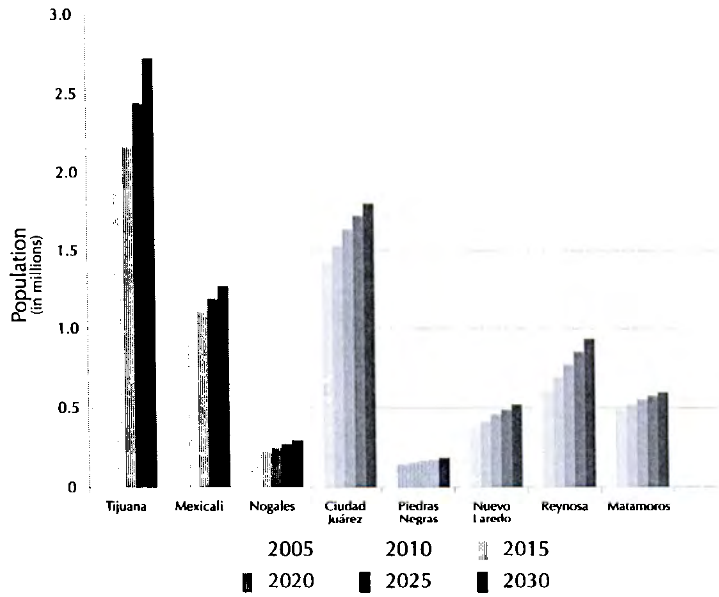
The rapid growth of the population over the last 30 years is closely linked to the high rates of urbanization; 90% of the population is located within the main border sister cities. Unfortunately, the physical growth of these urban area spaces has not been accompanied by a corresponding growth in public services. This growth has, however, been reflected in the increase of waste, higher energy usage, and changes to land use, among other consequences.

Population projections for Mexican border cities to 2030 indicate a strong population growth and concentration. The city of Tijuana will surpass 2.5 million inhabitants by 2030. However, if the growth of its neighboring cities (Tecate and Playas de Rosarito) is taken into account, then the challenges for this urban area are even more complex. Mexicali, Ciudad Juárez, and Reynosa have also experienced significant population increases. This rapid increase in population raises important questions regarding the measures that should be adopted by authorities and residents in order to address sustainable urban development, providing residents with improved urban infrastructure and services as well as protection for the environment (see Figure 3).

The semiarid characteristics of the region could cause many to assume that the infrequency of intense rains, tropical cyclones, or flooding would mean that these phenomena would not be an important consideration for policymakers. But it is precisely the *infrequency* of these phenomena that could actually increase social vulnerability.

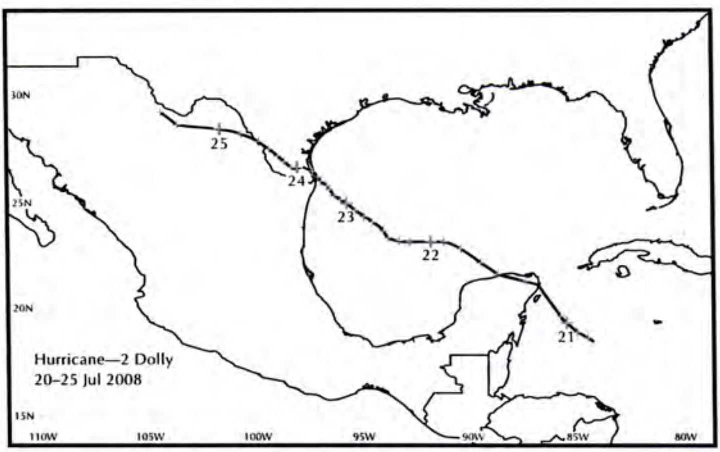
In fact, intense natural phenomena associated with the climate have caused economic and environmental damage as well as the loss of human life in the border region. For example, in July 1988, Hurricane Dolly affected an area extending from the Tamaulipas-Texas border area to Ciudad Juárez, Chihuahua, causing severe damage and losses. The path of the hurricane occurred right along the U.S.-Mexican border (see Figure 4).

Figure 3. Total Population Projected for the Main Mexican Border Cities (2005–2030)



Source: CONAPO 2006a, 2006b.

Figure 4. Hurricane Dolly's Path, July 2008



Source: UNISYS: http://weather.unisys.com/hurricane/atlantic/2008H/index.html.

The damage caused by Dolly began as it reached the border area. On July 23, 2008, more than 50 mm fell in northern Tamaulipas. The rain amount began to decrease as the hurricane lost power and moved inland. At the same time, its radius of influence combined with a huge mass of air from the Pacific Ocean and thus affected Ciudad Juárez-El Paso. Figure 5 shows the distribution of rain accumulated on the Mexican side of the border.

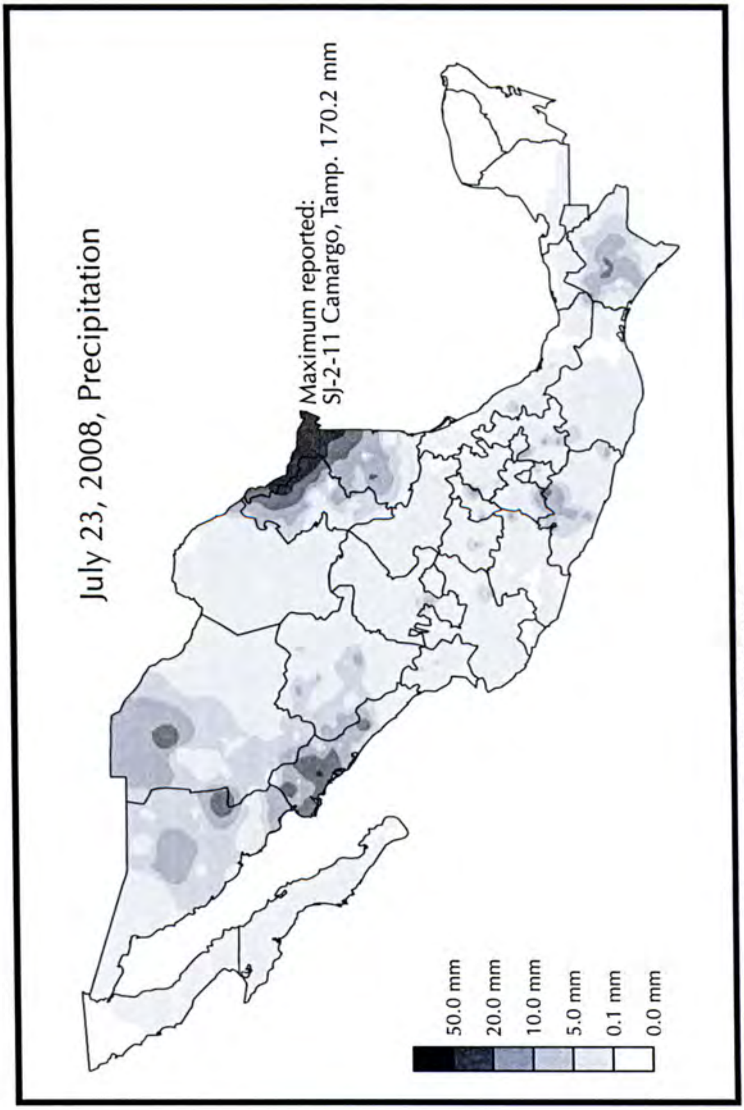
Tamaulipas was one of the most impacted states in Mexico and Hurricane Dolly caused damage in its residential, education, communication, and transportation sectors as well as to its hydraulic, urban, and electric infrastructure. The reconstruction funds from the National Disaster Fund (Fondo de Desastres Naturales–FONDEN) are shown in Table 1.[1] It is worth mentioning that this assistance did not necessarily cover the total economic losses suffered both during and after the emergency. Rather, these funds were basic resources for the local population and authorities to use in order to recuperate as quickly as possible and to return societal activities to normal.

Table 1. Authorized Reconstruction Resources from FONDEN

Affected Sectors	Restoration Actions	Federal Contributions*	State Contributions*	Total*
SEDESOL (living)	676	6,086,193	2,608,368	8,694,561
SEDESOL (urban)	66	10,000,359	40,001,438	50,001,797
SCT (state)	28	10,240,775	10,240,775	20,481,550
CONAGUA (state)	2	531,207	531,207	1,062,414
CONAGUA (municipal)	39	19,488,744	29,233,115	48,721,859
SEP (federal)	2	9,459,374	--	9,459,374
SEP (state)	1	302,796	302,796	605,592
Total	**814**	**56,109,448**	**82,917,699**	**139,027,147**

* In Mexican pesos.
Source: National System of Civil Protection. Secretaría de Gobernación. Consulted 14 January 2010, at http://www.proteccioncivil.gob.mx/fonden.

Figure 5. Total Daily Precipitation Associated with Hurricane Dolly



Source: Secretaría de Gobernación-CENAPRED 2009.

Tamaulipas was the fifth state in Mexico to receive FONDEN resources, after Veracruz, Oaxaca, Chihuahua, and Sonora. In regard to the latter two states, there was also intense rainfall, but in the southern part of both states away from the border area.

For the state of Texas, $44 million were used for public assistance purposes. U.S. residents are more protected than their Mexican counterparts since urban property and infrastructure generally are privately insured. This transfer of risk from society to the U.S. private sector is an important reason why the U.S. is less vulnerable economically to natural disasters (see Table 2).

Table 2. Reconstruction Resources Used for Hurricane Dolly in Texas

Area	Contributions (millions of dollars)
Housing	30.0
Commerce and business	9.8
Cleaning	4.7
Total	**44.5**

Source: U.S. Federal Emergency Management Agency. Consulted on 15 January 2010, at: http://www.fema.gov/news/newsrelease.fema?id=46258.

In addition to hurricanes, intense rains, and flooding, the border area also experiences other extreme weather-related phenomena such as drought and wildfires. Drought occurs when the monthly or yearly average precipitation of an area is significantly lower than the historic average registered within that area. Examples are the recent droughts in Baja California, Sonora, and Chihuahua, which have impacted the agricultural sectors as well as urban areas.

In addition, drought often brings on forest fires, which happen regularly in Southern California and northern Baja California. For example, during the fall of 2007, 23 fires occurred in an area extending from Los Angeles, California, to Ensenada, Baja California. These fires were exacerbated by the Santa Ana winds, dry offshore winds, which are common in this region during the fall and winter.

They destroyed a total of 2,300 homes; more than 12 people died. Over 2,100 km² were affected in San Diego alone, where the damage reached one billion dollars (Reuters 2007).[2]

Projections for Tijuana to 2030

The city of Tijuana, Baja California, experienced intense rain during the winters of 1982–1983, 1992–1993, and 1997–1998. These rains were associated with the El Niño Southern Oscillation climatic phenomenon. Most of the city experienced flooding, which isolated urban zones and caused damage to urban infrastructure, cutting off electrical power and causing the loss of human life. There were 41 deaths registered in 1993 alone (see Table 3). The aforementioned impacts are associated with, among other effects, the increase of global vulnerability to human settlements along the border.[3]

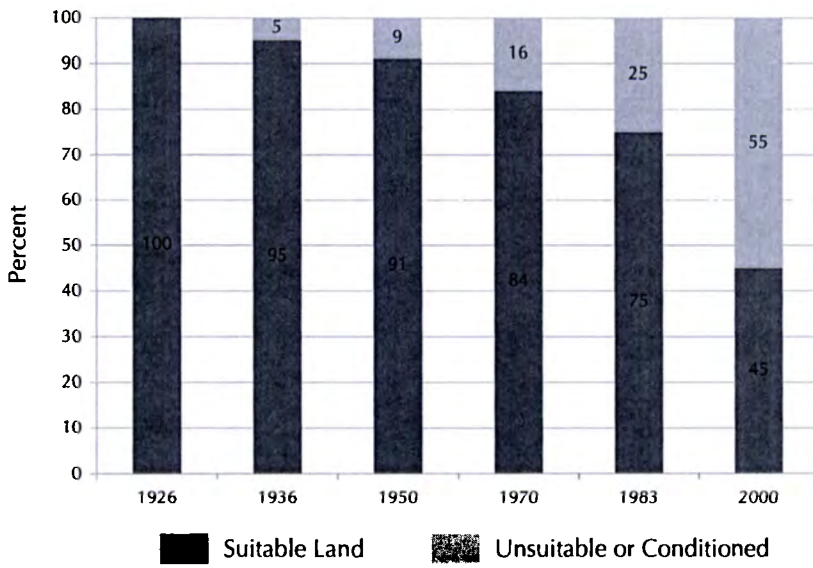
Table 3. Losses Associated with Intense Rainfall along the Tijuana River Basin

Year	Human Deaths	Economic Losses (millions of pesos)
1978	4	100
1980	0	58
1983	5	119
1993	41	150
1998	15	198
Total	65	625

Note: Human deaths refer to those that occurred during the rainfall. Economic losses are at then current prices and only refer to those reported by local authorities (loss of urban infrastructure) for reconstruction.
Source: *El Mexicano*, Tijuana, B.C.

The data from Table 3 show the increases in human and economic losses, which could have resulted from a series of factors such as the intensity of rainfall, the volume of water in the subbasins, exposure of the population at risk, and population growth, among other factors. However, one must take into account the demographic and urban history of the border region, particularly with regard to a growing population located in areas not apt for urbanization such as hillsides, canyons, and flood-prone areas. Accelerated urban growth, population growth, lack of public services, and so on, may generate an increase in global vulnerability due to extreme climatic phenomena. As an example of this, Tijuana's urban growth has taken place because of the occupation of areas unsuitable for human settlement, as shown in Figure 6.

Figure 6. Suitability of Land for Development in Tijuana, B.C. (1926–2000)



Source: Juan Jorge Rodríguez and María del Rosario Cota, 1997. Tijuana City Government-IMPLAN. Urban Development Program of the Tijuana Population Center of Tijuana, B.C., 2002–2020, 2002; Rodríguez Esteves, 2007.

Pursuant to Figure 6, beginning in the 1970s, Tijuana began to grow into areas not suitable for urbanization. There are a number of factors behind this trend, including the following:

1. High urban growth rates: During the 1970s, there were urban population growth rates that reached 7.8 per year, with a population density of 49 residents per hectare.

2. The lack of urban planning associated with the rapid population growth.
3. Urban growth became more intense in the southern part of the urban center, particularly in an area of hills and ravines.
4. The lack of urban infrastructure was due to high immigration flows and the difficult topography that made installation of infrastructure projects very costly.
5. Lack of sufficient land set aside for urban growth caused settlements to develop in certain high-risk areas.
6. Temporary residence: For many years, people came to Tijuana with the intent to cross into California but ended up establishing residence in Tijuana.
7. Perception of risk: The need to have land in order to build houses caused much of the population to ignore or minimize the risk of disaster.

These factors still exist to one degree or another; however, the risk of disaster is built upon a set of social, economic, political, environmental, and cultural factors. This becomes relevant when one considers that by 2030, the city of Tijuana will have 2.7 million residents. This will require greater investments in urban infrastructure and services as well as development of safe areas to build houses.

Priorities for Sustainability in the Region

The nature of the shared environment along the U.S.-Mexican border means that events, even disasters, in a Mexican border city can have direct implications on its neighboring U.S. city. Watersheds are a clear example of when a resource that is shared by both countries can become a source of conflict.

The intense rainfall that can occur in the region can have different outcomes for both sides of the border. All border cities posses a certain degree of vulnerability with respect to intense rain, flooding, or wildfires.

In this sense, orienting development toward sustainability should start from a perspective of global vulnerability to climatic risk. This effort can begin by making cities safer with respect to the effects of climatic phenomena over time, which should translate into fewer people affected and smaller economic and infrastructure losses.

In order to have safer cities, it is important to reduce housing, public services, and urban infrastructure deficiencies and to focus on a transborder approach. This is critical because, if there is a natural environment shared by both sides of the border, then it is also imperative that the border urban centers share strategies to diminish risks. It is also important to work in a joint manner on educational initiatives and promote a culture of prevention regarding extreme climatic events with both citizens and local, regional, and national authorities. Therefore, binational collaboration mechanisms are needed in order to involve the main stakeholders and decision makers and strengthen the strategies in both countries in regard to the reduction of risk.

In fact, there are already mechanisms in place to reduce the risks from disasters on the Mexican side (even though they may be unilateral mechanisms). Most important are the municipal and state civil protection plans. These are mechanisms that identify the type of threats that are recurring at different scales along the border as well as the types of measures that should be implemented in case of an emergency. However, for a variety of reasons, it is very common for such mechanisms to be overwhelmed by the magnitude of these extreme climatic events.

Finally, one important priority for sustainability for the region that is addressing risks and disasters is an analysis of the principal threats confronting the region from a binational perspective. This analysis should include the capacity of the ecosystems for mitigating climate effects and the forms of local organization (including strengths and weaknesses) of groups that must address climate emergencies (including personnel, existing infrastructure, and equipment). An additional critical element of this analysis is to communicate the results to the border residents in both countries, since an informed population is less prone to specific threats.

Toward the Implementation of Public Policies in Sustainability

In the United States, there are agencies in charge of responding to the damage caused by disasters at the federal (Federal Emergency Management Agency [FEMA]) and local level. The legal framework for their work is found within the *National Response Plan* (2004), and the operational form to deal with the disasters is found within the *National Response Framework* (2008). With these instruments, U.S. authorities and organizations join forces in order to better coordinate the preparation, response, and reconstruction of areas damaged by a disaster.

In Mexico, the National System of Civil Protection (Sistema Nacional de Protección Civil–SINAPROC) is the general coordinating body in which the three levels of government and civil society are involved. SINAPROC organizes its governmental functions and powers with regard to civil protection in order to protect life, the environment, and community resources (SEGOB 2008).

SINAPROC operates through the National Council of Civil Protection, which is headed by the President of the Republic; the representatives of federal agencies; federal public administration organizations and institutions; the National Center for Disaster Prevention (Centro Nacional de Prevención de Desastres–CENAPRED); and volunteer groups, as well as the civil protection systems of the states, Mexico City, municipalities, and political delegations (SEGOB 2008). Sonora was the first Mexican border state to prepare an organizational strategy to confront the effects of disasters and to reduce risk. The state passed its civil protection law in 1993. Baja California is the most recent state to have such a law, which was passed in 1998.

The operational and formal organization with which the national governments work on disasters and the reduction of risk are based on domestic factors, but they do take into account the importance of international collaboration. Cooperation between border states has occurred on a case-by-case basis across the border during specific disasters in the region that have required an immediate response. For example, during the 1993 rains in Tijuana, the state of California and San Diego local governments sent personnel to the flooded areas as well as machinery to reconstruct some roads for transporting humanitarian aid to the affected residents.

There have been cases in which both countries cooperate to address threats of a natural origin. Such is the case of the Binational Integral Flood Alert System in the Tijuana River Basin—implemented in 2003—in which government institutions, universities, and other organizations from both countries participated. The purpose of this project is to supply real-time information on hydrological conditions of this shared basin for decision makers in order to protect the at-risk population from harm.

Up until now, governments at various levels in both countries have focused on planning in order to deal with contingencies. However, a truly integrated approach should include local, regional, and federal authorities as well as community groups, civil society, binational organizations and stakeholders, and international organizations from a preventive perspective. Binational cooperation throughout the creation of transborder institutions such as the International Boundary and Water Commission (IBWC), the Border Environment Cooperation Commission (BECC), the Border 2012 Program, and the San Diego Association of Government's (SANDAG) Committee on Binational Regional Opportunities (COBRO) are success stories that can be considered in order to create a Binational Preventive Plan for Natural Disasters (Plan Binacional Preventivo ante Desastres Naturales–PBPDN).

The PBPDN should undertake critical binational planning in order to address the impacts of extreme climatic events and avoid, to the extent possible, the negative consequences of disasters. Within such a plan, local, regional, and national authorities should be consulted for their coordination, incorporating the different sectors of society from both sides of the border in order to implement risk reduction strategies. In addition, technical and scientific support of an Early Warning System for the Border between Mexico and the United States (Sistema de Alertamiento Temprano para la Frontera entre México-Estados Unidos–SATFMEU) should be created. This organization's critical information would warn the population and provide information for key governmental agencies.

Final Comments

Climatic phenomena in the U.S.-Mexican border region can become more intense within the context of climate change. The intense rains of the recent past are evidence that the cities within the region are vulnerable to the extent that the population and infrastructure become more exposed to this type of phenomena. Also, drought is another phenomenon that should be considered when it comes to risk management of cities. In the future, drought can grow to be an important threat if not addressed.

The accelerated growth of cities, mainly on the Mexican side of the border, can generate risk for disaster scenarios. In recent years, the effects of intense rains have demonstrated the degree of vulnerability of the areas in which new human settlements have developed, mainly within city limits.

In order to reduce the exposure of the population and reduce its vulnerability regarding intense rains and their effects, we should understand that although we live in a semiarid area, the border region's cities are vulnerable to phenomena such as drought and intense rainfall. Therefore, we need to construct a type of urban infrastructure that reduces the risk of disaster as urban population grows. Current risk disaster management should be reoriented toward integral risk management, which takes into account the organizations, institutions, protocols, binational agreements as well as the participation of the population, especially those people that are most exposed to intense phenomena. Any initiative that pretends to decrease vulnerability but does not involve the actors that participate in the construction of the risk of disaster is doomed to failure.

In order to reach these objectives, it is necessary to begin to orient public policy in both countries toward joint efforts through: (1) analysis of the main threats that affect the region from a binational perspective; (2) an Early Warning System for the Border between Mexico and the United States (SATFMEU); and (3) a Binational Preventive Plan for Natural Disasters (PBPDN).

Endnotes

[1] The National Disaster Fund, better known as FONDEN, is a financial instrument. Through this fund, the National System of Civil Protection in Mexico supports states within the Mexican Republic and the Federal Public Administration dependencies and entities in regard to attention and recovery from effects produced by natural phenomena, in compliance with the parameters and conditions foreseen in its rules of operation (Federal Government 2010).

[2] Other news media sources reported that the coverage total reached $1.6 billion for housing and local commerce only (Notimex 2007).
[3] The term "global vulnerability" is associated with different societal dimensions in which society as a whole is more vulnerable with regard to threats of a natural origin. These dimensions can be natural, social, economic, political, and cultural.

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XIII

Engaging the United States and Mexico in Defense, Development, and Diplomacy to Enhance Sustainable Security at the Border

Erik Lee, Carlos de la Parra, D. Rick Van Schoik, and Sara Sonnenberg

> The United States seeks a safer, more prosperous, more democratic and more equitable world. We cannot reach that goal when one-third of humankind live in conditions that offer them little chance of building better lives for themselves or their children.... We cannot build a stable, global economy when hundreds of millions of workers and families find themselves on the wrong side of globalization, cut off from markets and out of reach of modern technologies. We cannot rely on regional partners to help us stop conflicts and counter global criminal networks when those countries are struggling to stabilize and secure their own societies.
>
> —U.S. Secretary of State Hillary Clinton
> January 6, 2010

Introduction

In one of her first major addresses of 2010, Secretary Clinton laid out the Obama Administration's approach to development in a lengthy speech at the Center for Global Development in Washington, D.C.

Although she specifically mentioned Mexico only once in the speech, a number of the concepts she articulated could easily apply to how the U.S. would have liked to expand its relationship with Mexico, going forward through *partnerships* and *investment* instead of traditional aid; *development* as a coequal with defense and diplomacy; and *innovation* and *knowledge exchange*. The principal difference with how the U.S. approaches development partnerships with other countries from how it approaches development issues with Mexico, of course, is that the two countries share an almost 2000-mile border, the locus of complex binational interaction on all levels, a true "system of systems."

Without a doubt, the terrorist attacks upon the United States on September 11, 2001, catalyzed an intense and contentious reshuffling of the nation's priorities, and particularly with respect to how it manages its border with Mexico. The Homeland Security Act of 2002 created the Department of Homeland Security (DHS) and grouped 22 component agencies under its umbrella. The REAL ID Act of 2005 gave the DHS Secretary the power to waive environmental and other laws and regulations that interfered with or delayed the construction of physical barriers at the border. Following a number of false starts, according to the U.S. Customs and Border Protection (CBP) website, as of April 29, 2011, CBP had completed 650 miles of fencing (351 miles of primary pedestrian fence and 299 miles of vehicle fence) along the Southwest border.

The Good Neighbor Environmental Board (GNEB), a key advisory board to the federal government, acknowledged the expansion in the importance of border security operations in its March 2007 Tenth Report to the President and Congress of the United States, *Environmental Protection and Border Security on the U.S.-Mexico Border*. The GNEB also added two additional key factors related to the increase in border security operations: the spike in illegal immigration as well as the increased violence in Mexico associated with Mexico's ramped-up efforts to contain the various drug trafficking organizations. While the GNEB report took pains to point out that, in certain circumstances, the enhanced fencing actually *protected* environmentally sensitive areas, the report outlined nine major challenges (Table 1) to the border environment that result from border security activities related to undocumented migrant crossings and hazardous materials management.

However, if the three pillars of statecraft and the U.S. national security policy are defense, diplomacy, and development, then the current public policy discussion on border security infrastructure and its environmental effects may focus too heavily upon a still too narrow definition of security that potentially misses all three "Ds." An enlarged definition of national security and pursuit of human security can potentially accomplish all three. The bottom line for all environmental work should be the human condition and, even more specifically, human security. This broader, dimensionalized definition of security includes components such as energy, water, infrastructure, natural disasters, biological hazards and threats, food and agriculture, natural habitats, hazardous materials and chemicals, and infectious diseases. This broader definition of security offers the United States and Mexico several opportunities and win-win situations for both the security and environmental communities.

Impacts of Border Security Policy, Infrastructure, and Activities

The impacts of border security operations—to the natural world and to the human world—are myriad and diverse.

Ecological Upset. The fence bisects otherwise intact ecosystems, assemblages of species, natural communities, habitats, and natural processes such as hydrology and fire. Flesch et al (2009) document the destruction of "connectivity" claiming two dimensional (for terrestrial species) and three dimensional (for aerial or flying species) obstruction and fragmentation of home range and territory. They observe that, "Vegetation gaps and tall fences may limit transboundary movement" thus lowering otherwise "relatively high levels of gene flow and migration, and dispersal. Disruption of transboundary movement corridors by impermeable fences would isolate some populations" and spatial distributions may be "affected by border development."

Table 1. Areas of Focus and Principal Challenges for Border Security and the Environment

Area of Focus	Challenge
Undocumented Migrant Crossings	1. Roads and foot trails created by undocumented migrants, migrant smugglers, and drug smugglers as well as by the interdiction agencies that pursue them cause damage to wildlife and fragile ecosystems.
	2. Trash and other waste left by undocumented migrants and drug smugglers in the process of crossing despoils the landscape and puts people and wildlife at risk for disease.
	3. Impenetrable fences may present significant negative consequences to wildlife and the environment.
	4. Lack of collaboration across agencies with responsibility for border security, land management, and environmental protection tends to lessen the likelihood of win-win scenarios for both security and the environment.
Hazardous Material Crossings	5. Ports of entry lack staff to inspect all shipments of hazardous materials, including hazardous waste, and some local emergency responders have inadequate training. Environmental agencies also lack hazmat tracking data as well as more general chemical storage data. Although CBP prescreens shipments before leaving 32 foreign ports, it does not do so at land ports in Mexico.
	6. Emergency responders are not able to easily cross the border to respond to incidents because of insurance, liability, national sovereignty, and command issues; customs and border procedures may delay response.
	7. Technology equipment and personnel issues: environmental protection needs of small U.S. communities, Mexican communities, and U.S. tribes are overlooked in the "big picture."
	8. An overarching strategic plan for border region ports of entry is needed that reflects development, population, language, and staffing requirements, which also would lessen tensions that exist between security and environmental protection personnel at some ports of entry.
	9. Tribal funding and communication pose a challenge, specifically the inability of border tribes to directly receive federal funding for emergency response and less than desirable communication on hazardous materials transported through and adjacent to tribal lands.

Source: GNEB 2007.

In some places where fences have been constructed for political or ownership reasons, those fences are being removed for the benefit of species. In the Carrizo Plain National Monument in central California, fences are being removed to save the pronghorn antelope, which were introduced in 1990 but needed more ranging room to survive and prosper. A press report in 2009 noted that, "The long stretches of fence spread across the range prevent the pronghorn from fleeing predators and are a big reason why the herd has the worst survival rate in the west" (Cone 2009).

A genetic migration workshop in 2007 cited several large animals as at risk from habitat bisection—the bighorn sheep of the Californias, the bears of the Río Bravo/Grande, and several species of birds, some of which do not fly high enough to cross the fence.

Ecosystem Processes and Services. Biologists and environmental economists attempt to value the natural world and their estimates range to trillions of dollars of service to humanity annually. Suffice it to say that destroyed habitat without mitigation is lost productivity, quality of life, and future vitality. Specific services offered by habitat in the border include the filtering and nursery services offered by estuaries; the creation of oxygen and filtering of pollutants performed by habitat; the sedimentary and nutrient value of hydrological flows and processing; the home for, and creation of, niches to all species by riparian sky islands and other rare or endangered biomes; and the natural and esthetic value offered to birders and other naturalists.

Cooperation and Mutual Aid. Former California Governor Arnold Schwarzenegger is fond of telling the story of being awakened late one night by President Felipe Calderón, who was flying over California to a meeting in Asia. The president declared "California is on fire. What can I do?" This anecdote about what neighbors naturally do to assist each other is tempered by the reality that since 2001 almost all U.S.-Mexican cross-border operations are harder, more time consuming, arduous, or tense. Victor Konrad of Carleton University in Canada has even done a survey to document the extra effort needed and binational coordination that does not occur due to friction and border thickening (Konrad and Nicol 2008).

Avenues of Exploration to Address Impacts. If indeed sovereignty is seen as an obstacle to cooperation, as discussed at Border Institute VI and Border Institute IX, there are mechanisms for transnational sovereignty, sovereignty bargaining, or sovereignty sharing. U.S. Ambassador to Mexico Carlos Pascual has even written in his latest book (Jones et al. 2009) that 21st century diplomacy needs to be based on a shared responsibility and collaborative action. Pathogens and hazardous materials flow across borders more easily than cooperation for fighting them, necessitating elaborate planning, preparation, and preparedness for all natural disasters as well as intentional damage-inducing events. Some of that effort may require one nation or the other to give up some degree of absolute control of its border or homeland, laws or regulation, peoples or process.

Taking an "All-Hazards" Approach to the U.S.-Mexican Border

Planning that only takes security issues, environmental issues, economic issues, U.S. issues, or Mexican issues into consideration can be counterproductive and generate significant unintended consequences. However, an all-hazards approach to risk mitigation that takes a number of key issues into consideration when attempting to solve any one problem (e.g., illegal immigration) has the potential to be richer, more longer lasting, and more sustainable. An all-hazards approach to the U.S.-Mexican border applies a framework to view the borders as a "system of systems," or an interconnected junction of both spatial and conceptual areas, where various key systems meet, intersect, and affect one another, including bi- and trinational communications networks, levels of governance, law enforcement, security tools and approaches, and migratory populations, among other areas. Considering hazards collectively, rather than singling out individual threats, and focusing on the U.S.-Mexican border as a dynamic point of intersection, border security measures should adopt an integrated approach that detects and classifies all types of illegal and high risk border crossers, including drugs, undocumented migrants, weapons, bulk cash, and precursor chemicals. An all-hazards approach is holistic and multifaceted and allocates resources according to risk, rather than perceived threat. Examples of this multifaceted planning are presented in Table 2 and are grouped within seven themes or binational issue areas, often together with cautionary cases where an all-hazards approach was not applied.

Table 2. Overview of Binational Issue Areas

Binational Areas	Security Issues	Key Partnerships Needed
1. Energy	U.S. heavy dependence on and access to petroleum	Binational mechanisms to ensure cleaner, more stable energy production
2. Water	Wastewater overflow from Mexico into the U.S.	Binational wastewater treatment facilities
3. Ecosystems and Habitats	Invasive plant species that prevent proper patrol of border regions by law officers	Binational teaming with tribal nations that reside in border regions to remove invasive plants
4. Human Health and Quality of Life	H1N1 influenza epidemic and mitigating virus spread	Trinational/binational collaboration and communication of scientific findings, other resources
5. Natural Disasters and Intentional Acts	Transboundary forest fires	Binational planning to prevent and respond to forest fires and other security risks
6. Infrastructure	Closing or restricting traffic at ports of entry (POEs)	Binational collaboration for increased security measures on either side of POEs
7. Hazardous Materials and Waste	Loss of funding for the HazTracks effort to classify and identify hazardous waste crossing the border	Binational planning and funding of a transboundary hazardous waste management facility or system

Source: Authors.

Multifaceted Energy Planning. Mexico is the third largest supplier of petroleum to the United States; the U.S. economy depends heavily upon access to this key commodity. Efforts to integrate the regional energy sources, markets, and infrastructure have the potential to ensure security to both sides. Exchange of renewable energy (and their credits), joint mitigation of greenhouse gases, trade of emission reduction credits, and other binational mechanisms can ensure a cleaner and more stable energy picture. The U.S.-Mexico Bilateral

Framework on Clean Energy and Climate Change of 2009 offers some hope in this area. Projects at the border offer an opportunity to ground this agreement in a concrete and highly beneficial context.

Multifaceted Water Planning. One of the oldest, most successful, and institutionalized mechanisms of collaboration between the United States and Mexico is the International Boundary and Water Commission/Comisión Internacional de Límites y Aguas (IBWC/CILA), established in 1889. In addition, the relatively recently created North American Development Bank and Border Environment Cooperation Commission have been instrumental in evaluating plans for and then funding several successful binational wastewater treatment plants, such as those in Ambos Nogales (Arizona-Sonora) and Dos Laredos (Texas-Tamaulipas). If properly planned, binational wastewater treatment plants can save the United States and Mexico millions of dollars. They are usually more strategically located than unilaterally planned facilities and generally are less expensive to implement, yet they do provide effective treatment consistent with the highest standards of either country. Moreover, binational planning offers Mexico the technological and financial resources it needs to adequately treat its wastewater—wastewater that, in many occasions, flows into the United States.

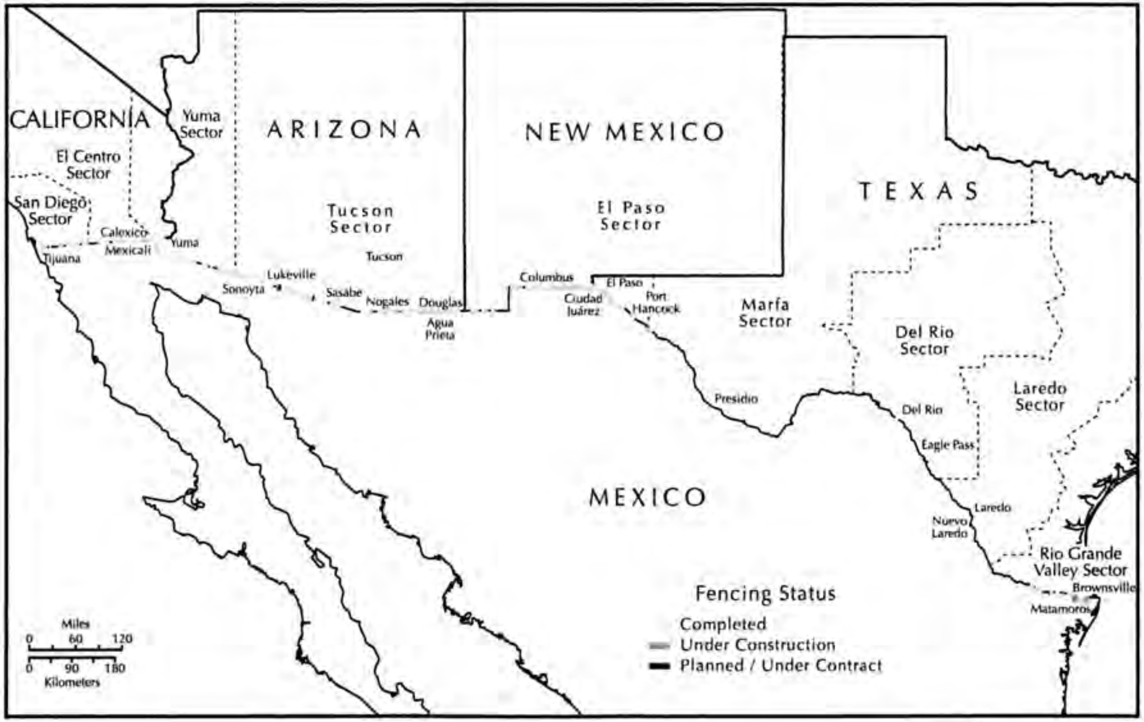
Multifaceted Ecosystems/Habitats Planning. Since 2005, the United States, Mexico, and the Cocopah Nation have teamed to remove tamarisk, or salt cedar, and other invasive plant species that have explosive growth rates. These species are choking sections of the river bank on the Cocopah reservation that are on the Colorado River where it serves as the boundary between the United States and Mexico. Not only is this binational project restoring the Colorado's natural ecosystem and hydrological processes, but the removal of the dense vegetation is enhancing the ability of law enforcement officials to see and patrol the river and border in areas that were once major crossing points for illegal entrants. The removal has also allowed law enforcement officers to determine the border location unambiguously. Finally, the project has restored native plant communities, some of which are important culturally and economically to the Cocopah people.

As has been pointed out before in several venues, scientists have discovered that fences along the U.S.-Mexican border can, in the right contexts, *protect* the environment, as they prevent migrants from creating permanent trails from their foot traffic that increases erosion, littering, and ignition of unintentional wildfires. Virtual security fences, such as the fence security system that until recently was becoming operational along the Arizona-Sonora border as part of CBP's Secure Border Initiative Network (SBI*net*), can potentially be used to detect and track rare mammals, such as the jaguar. SBI*net* systems combine technologies such as mobile and fixed towers, cameras, radars, and unattended ground sensors. Combining good ecological practices with advanced technologies, such as the control of sediment to prevent security sensors from being buried, ensures greater security along the Southwest border. Figure 1 provides an overview of SBI*net* virtual fence construction. Due to problems the contractor had with development and deployment, the virtual fence project was cancelled by DHS early in 2011. Nonetheless, the concept of securing areas of the border with a smaller footprint and minimal environmental impacts remains of great interest to those concerned about the environmental effects of this large law enforcement infrastructure project.

Unilateral Food/Agricultural Planning. The United States' decision to subsidize corn and the growing of corn for the ethanol market—when combined with the free trade of agricultural products as guaranteed by the North American Free Trade Agreement (NAFTA)—has had a significant impact on the Mexican corn market. The decline of corn prices in many areas of Mexico has made traditional corn producers noncompetitive and many Mexican farmers have migrated north to the border and elsewhere in the U.S. in search of work.

Multifaceted Human Health and Quality of Life. Health is often one of the priority issues of human security. Large population movements, limited public health infrastructure, and poor environmental conditions contribute to increased risk for infectious diseases in the border region, especially at the U.S.-Mexican border where more than 14 million people reside. The Border Infectious Disease Surveillance (BIDS) program has been extremely successful in detecting infectious diseases before they cross the U.S.-Mexican border. BIDS owes much of its success to its policy of collaboration among U.S. and Mexican

Figure 1. Status of Border Fence Construction (as of December 2009)



Source: http://www.cbp.gov/linkhandler/cgov/newsroom/highlights/fence_map.ctt/fence_map.pdf stakeholders and scientists. Other efforts provide important collaborative experiences as well. In 2007, the now-defunct Security and Prosperity Partnership released the North American Plan for Avian and Pandemic Influenza, which focuses on detection, containment, and control; preventing entry into North America; minimizing illnesses and death; sustaining infrastructure; and mitigating impacts to the economy and functioning of society.

The recent trinational collaboration on the H1N1 influenza response serves as a model for collaboration. The three North American governments worked closely together from the beginning of the H1N1 outbreak in 2009 through the sharing of information and resources to implement evidence-based strategies in the countries and on the borders to ensure health safety. Quarantine, by its very nature, is a failed exercise because it more or less assumes that other infected people have already crossed and contaminated the native population. Collaboration and communication between nations and citizens were the most effective means of mitigating the spread of the virus, proven by both the U.S. and Mexico acting like good neighbors. Mexico responded through early announcements of the influenza epidemic in Mexico and used two epidemiologic surveillance systems to classify and identify patients and suspected influenza cases to isolate the H1N1 strains. The U.S. assisted with medical detection work and kept the border open.

Multifaceted Planning for Natural Disasters and Intentional Acts. According to the tenth report of the Good Neighbor Environmental Board (2007), California and Baja California have successfully planned and implemented strategies to fight transboundary wildfires. The Board report notes that, "Under this agreement, Mexican fire agencies have crossed into San Diego County to assist local fire fighters on a number of occasions. In addition, U.S. agencies regularly provide assistance south of the border." Not only does this form of binational planning create more effective responses to wildfires than does a unilateral effort, but it also provides San Diego and Tijuana with mechanisms and strategies that can be easily used in responding to potential transboundary terrorist attacks. The binational Border Area Fire Council, which was originally created to respond to fires created by migrants, has led to other binational cooperation on fire prevention, transboundary prescribed burns, natural resource management, joint emergency response training, and equipment exchange.

Unilateral Natural Disaster and Infrastructure Planning. Recent surprise rainstorms have flooded communities at different locations along the border, closed businesses, and even drowned a few people. Proper infrastructure planning, which is integrated across the border and linked to drains on either side, could have lessened the impacts. For example, use of drains between Nogales, Sonora, and Nogales, Arizona, for smuggling activities led to installation of barriers in storm drains by the U.S., which then caused flooding during the next rainstorm.

Hazardous Materials and Waste. The provision of NAFTA that required that hazardous waste from materials used in the production of Mexican maquiladoras would be "repatriated" to the U.S. until such time that Mexico developed an adequate storage, transport, and disposal system for the hazards had the clear intent to protect and improve the health and safety of border residents. HazTracks, the binational system intended to track hazardous waste as it crossed the U.S.-Mexican border was never fully functional and eventually lost its funding. Therefore, a new arrangement to track and manage hazardous waste from Mexico needs to be established.

U.S.-Mexican Border Environment and Security: Key Opportunities

The Good Neighbor Environmental Board Report

The Tenth Report of the Good Neighbor Environmental Board to the President and Congress of the United States, ***Environmental Protection and Border Security on the U.S.-Mexico Border***, published in March 2007, noted the negative environmental effects of both illegal immigration (new networks of roads and large amounts of trash and other refuse left by migrants in environmentally sensitive areas) and intensified security operations by the U.S. Department of Homeland Security. It also emphasized the positive effects for the border environment and the U.S. and Mexico with respect to some fencing that protects sensitive ecological and cultural areas. More specifically, it highlights the convergence of interests of the security and environmental communities for the close management of hazardous materials entering at the dozens of ports of entry along the border. The following outlines additional areas of opportunity beyond these specific areas of ecological protection and hazardous materials management.

Opportunity 1: Consultation on Environmental Impact

A tool with potential significant benefits for the border region is the long-proposed Transboundary Environmental Impact Assessment (TEIA), which presents a significant opportunity for collaboration between the United States and Mexico to avoid negative environmental spillover effects across the border. The North American Agreement on Environmental Cooperation (NAAEC) among the U.S., Canada, and Mexico was agreed to as part of NAFTA. The NAAEC created the trilateral Commission for Environmental Cooperation and included language for establishment of a TEIA process. Unfortunately, a TEIA has yet to be implemented among the NAFTA partners or even bilaterally.

TEIAs could play a central and beneficial role not just for environmental impact minimization, monitoring, mitigation, and management, but also for North American diplomatic relations more broadly. In addition, TEIAs could build upon cross-border environmental work that has evolved through binational programs such as Border 2012; in many cases, the environmental arena is one of the most positive and productive areas of interaction between the United States and Mexico. If the U.S. would consider use of TEIAs for infrastructure projects on the border, this would be an important step. From the U.S. perspective, this might be as straightforward as implementing strategic environmental assessments (SEAs), which are greater, more comprehensive, and more strategically oriented than the current programmatic and project environmental impact reports (EIRs) and environmental impact statements (EISs) that the various federal agencies currently implement. The use of SEAs is consistent with current U.S. practices and their implementation could lead to use of TEIAs.

So what is holding up this process? The divisive issues regarding TEIAs are actually few. Because environmental review is a federal domain in Mexico but a state jurisdiction in the U.S., disagreement persists regarding which projects would be subject to notification and the review process. The U.S. federal government could enable and facilitate U.S state communication with Mexican federal levels. While the U.S. side posts most reviews for public comment, that process is not official consultation. It should also be emphasized that TEIAs are but one of a host of underimplemented and underevaluated environmental and security agreements between the United States and Mexico. The 1983 La Paz Agreement does not address the border fence infrastructure; neither do the 22-point 2002 Smart Border Agreement, the Security and Prosperity Partnership, nor the 2009 Mérida Initiative address the border wall in any substantive way.

Yet the current construction, operation, and patrolling of virtual and actual fences raise the issue of transboundary environmental impact and assessment to a new level of importance. The obvious and binationally recognized impacts of the border fence and associated infrastructure center on the division of contiguous ecosystems and all of their parts. The REAL ID Act of 2005 gave the Secretary of the U.S. Department of Homeland Security both exclusions and exemptions to environmental review when security—in the judgment of the Secretary—would be jeopardized by compliance or the implied delay of implementation. However, the Act does not specify that *transborder* effects of the fence are also exempted. This is important because the considerable and negative diplomatic effects of both building a wall between neighbors and the lack of notification over its environmental impacts are an example of what can happen when the environment and security are not considered holistically in border policymaking (for the purposes of space we are not bringing the fence's impact upon *competitiveness* into consideration here).

Opportunity 2: Effectively Leverage Technology, Infrastructure, and Cooperation

Technology plays a role in securing our nation's borders, although we need to think through its sustainable implementation. The use of unmanned aerial vehicles (UAVs) or drones and satellites even further away is suggested. The Schengen free travel zone of the European Union is monitored by satellites and the U.S. gave Mexico bandwidth on one of its satellites as part of the Mérida Initiative. Satellites could ultimately protect the environment, facilitate trade, and engender better U.S.-Mexican relations.

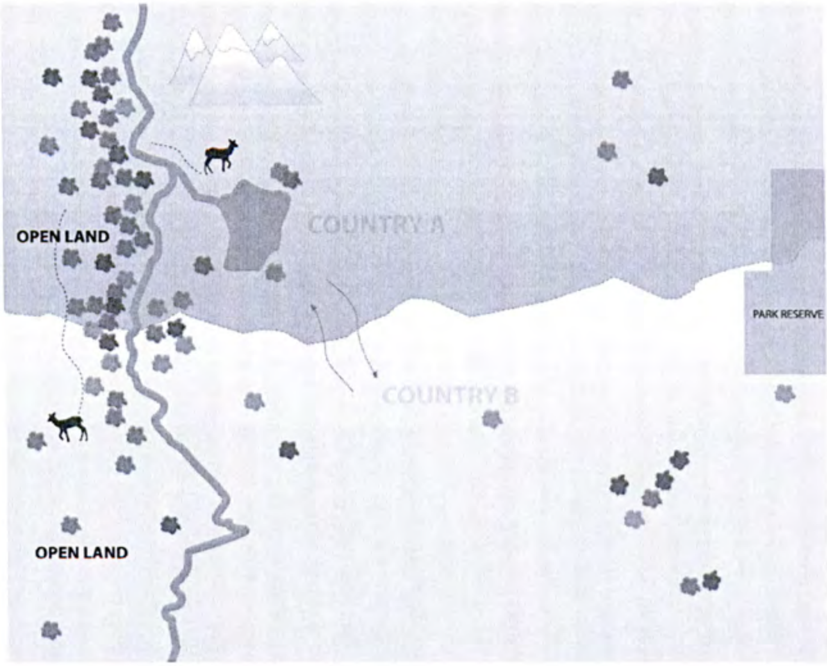
The potential successful use of satellites suggests that trade, security, and protection of the environment need not be seen as "pick one and delete the rest." Instead, security, environment, and commerce can coexist if codeveloped together. The following graphics show an example of how green infrastructure, or natural capital (Figure 2), can determine where human capital and economic infrastructure goes (Figure 3). Borders and security infrastructure are often then imposed onto the landscape to protect natural capital, but they need not destroy the environment nor create unnecessary tension between nations. Figure 4 shows how in remote and challenging terrain, such as with steep hillsides and riparian habitat, security infrastructure such as satellite telemetry, unmanned aerial surveys, balloon-lofted radar, and stand-off sensors can monitor activities and movements. In urban binational metroplexes, some fencing does make sense, if used intelligently with configurations such as binational customs teams. In other areas, a combination of fences and satellites makes sense. This combination allows energy, legitimate vehicle, personnel, and product transfer across the border yet affords control of the border.

Conclusion: Policy Options and Recommendations

It should be noted that the authors do not imply that stricter security or law enforcement is unnecessary at the U.S.-Mexican border. Instead, they suggest that the relationship between security and the environment should be studied further so that effective security measures that have fewer environmental consequences (or even enhance the environment and the economy), and that complement all aspects of security can be instituted at the border. They believe that the security-environment nexus offers a number of key opportunities for the U.S and Mexican efforts to manage their shared border.

In February 2009, the North American Center for Transborder Studies at Arizona State University launched the report, *North America Next: A Report to President Obama on Building Sustainable Security and Competitiveness*. The report contained eight main recommendations and a number of complementary recommendations. Some

Figure 2. Cross-Border Green Infrastructure

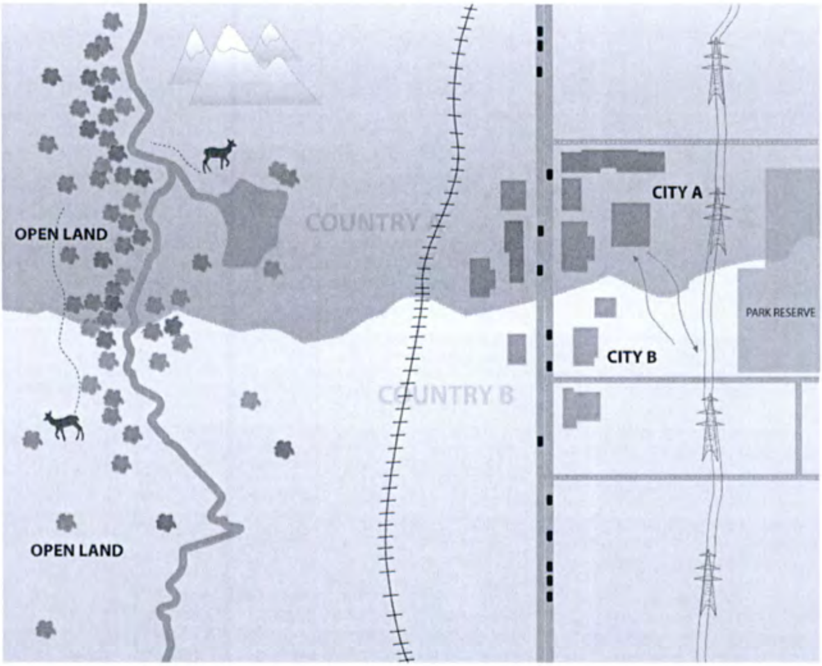


Source: NACTS.

of these recommendations are revisited here because of their insistence on the productive intersection of security, the environment, and economic competitiveness; these include the following:

Energize and expand the North American Trilateral Leaders' Summit. The summit is the highest profile example of North American cooperation and should continue with greatly increased participation from a number of key stakeholders and drawing on the work of existing regional entities—governors, legislators, nongovernmental organizations (NGOs), academics, advocacy groups—for solutions to needs throughout North America. These include the private sector and public-private partnerships that would perhaps interact at presummit meetings of NGOs, trade unions, academics, and think tanks. Involving the three federal legislatures as well as state, county, tribal, and municipal governments within the summit structure will deepen

Figure 3. Human Capital and Economic Infrastructure



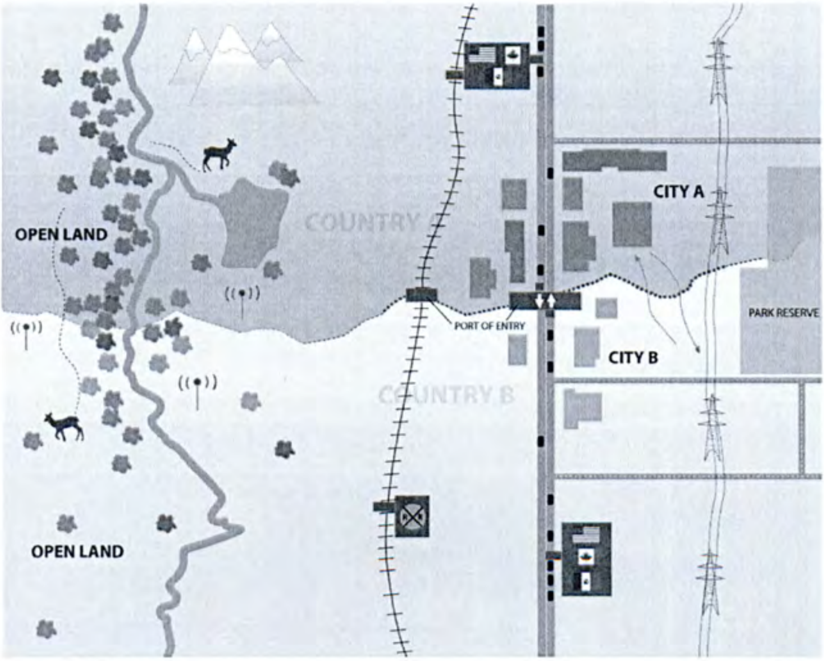
Source: NACTS.

and strengthen collaboration among the United States, Mexico, and Canada. Academic and public policy organizations could function at the center of a reinvigorated cross-border network.

Designate a North America/borders authority to coordinate sustainable security. A senior deputy at the National Security Council should be appointed to deal with and to resolve the competing, complementary, and overlapping border management, national security, law enforcement, commerce, transportation, environment, water, regional development, and other infrastructure and political issues that comprise today's border area realities. A singular focus on traditional security does not address all of the critical functions of the borders.

Expand joint risk assessment and preparedness with Canada and Mexico. Much of the security effort in the U.S. is focused on the prevention of another major terrorist attack. But this effort can be bolstered by the U.S. more effectively engaging its Mexican and

Figure 4. Smart Border Infrastructure



Source: NACTS.

Canadian neighbors as collaborators through enhanced joint defense of North America to minimize, mitigate, and manage natural and human-caused catastrophes in the three nations.

Create a joint, revolving fund for infrastructure investments in North America. Infrastructure in the United States, Canada, and Mexico is rapidly deteriorating and in urgent need of broad and deep investment. By pooling resources, the three countries can maximize the competitive benefit vis-à-vis Asia and Europe and jump-start their collective economic engine.

Establish joint and practical assessments of North American policy effectiveness. There is great need for practical and meaningful ways to guide and track progress on a number of key North American issues. These efforts should include tools such as a Cross-Border Collaboration Scorecard and an annual State of North America

Report (SoNAR) to be developed by North American academic and public policy organizations. The scorecard and report would inform the annual Trilateral Leaders' Summit.

Implementation of such ambitious objectives necessarily takes advantage of existing bilateral agreements, mechanisms, and institutions (of which there are many, as pointed out earlier). Organizations such as the Border Governors Conference, the Border Legislative Conference, and others provide perhaps the most strategic venues to focus on public policy at the security-environment nexus. And initiatives such as *The Strategic Guidelines for the Competitive and Sustainable Development of the U.S.-Mexico Transborder Region* (COLEF and Wilson Center 2009), commissioned by the Border Governors Conference and approved at its XXVII meeting in Monterrey, Nuevo León, in 2009, hold promise as a way to engage and focus key federal and regional stakeholders on security and environmental issues along the U.S.-Mexican border. Understanding the long-term security offered by a sustainable border environment can help put other security concerns into context and build sustainable approaches into these important binational efforts as well.

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XIV

The U.S. National Environmental Policy Act (NEPA) and Mexico's General Law of Ecological Equilibrium and Environmental Protection (LGEEPA): Barriers or Facilitators of Border Sustainability?

Elva Denisse Varela Olivas

Abstract

The National Environmental Policy Act (NEPA) and Mexico's General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente–LGEEPA) contain many provisions that could go a long way toward improving human and economic development in the U.S.-Mexican border region in an environmentally sound manner. NEPA and LGEEPA should be facilitators of border sustainability, but in practice, unexpected barriers for the implementation of both statutes have occurred, indirectly affecting the sustainability of the U.S.-Mexican border. This paper briefly discusses some probable reasons why neither nation takes full advantage of the potential of LGEEPA and NEPA to transform border sustainability.

This paper also describes a type of international legal instrument that could be created in order to minimize or eliminate some barriers of the legal systems of the United States and Mexico. However, many

of the existing legal barriers to border sustainability could be eliminated by improving the implementation of NEPA and LGEEPA—particularly in the area of environmental impact assessment—without changing these statutes. Barriers related to the implementation of LGEEPA in the area of environmental impact analysis and NEPA include: (1) the tendency to "over study issues," which disincentivizes the procedure on the U.S. side by negatively affecting decision-maker perceptions of the process; as a result, agencies try to avoid NEPA's applicability rather than embrace it as a valuable tool; (2) the tendency to limit the scope of studies due to a lack of resources and/or time on the Mexican side of the border, causing long-term consequences for border sustainability; and (3) an insufficient pool of skilled, available environmental professionals in the U.S.-Mexican border area. Although the body of NEPA and LGEEPA expertise has grown, agencies and ministries often do not assign their most effective and efficient personal to NEPA or LGEEPA tasks. Even though the head of an agency or ministry may be deeply involved in the trade-offs and the decisions affecting a proposal, the project drivers may be absent in the LGEEPA or NEPA processes.[1]

Introduction

The total length of the U.S.-Mexican border is 1,969 miles. The border region consists of six Mexican states and four U.S. states. This binational region is well known for its shared ecosystems and its sister cities. Throughout history, several laws directly or indirectly related to sustainability in the U.S.-Mexican border region have been approved by the Mexican and the U.S. congresses. According to the U.S. Constitution and the Mexican Constitution, both countries have federal legal systems. Therefore, the following analysis is limited to relevant national laws that are enforced throughout the U.S.-Mexican border region mainly by the respective federal governments.

This paper provides an overview of the legal frameworks for conducting environmental impact assessments for federally funded infrastructure projects within the border region. The focus of this analysis is to determine whether the Environmental Impact Assessment (EIA) processes in both countries sufficiently support the goals of sustainability in the border region. Specifically, are the U.S. National

Environmental Policy Act (NEPA) and Mexico's General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente–LGEEPA) barriers or facilitators of border sustainability? This paper does not pretend to provide a definitive answer but to serve as a useful guide for further discussion.

Origins of NEPA and LGEEPA as Promoters of Sustainable Development in the U.S. and Mexico

In December of 1969, the United States Congress enacted NEPA, which was signed into law by President Richard Nixon on January 1, 1970. NEPA was the first major environmental law in the United States and is often called the "Magna Carta" of environmental laws. Moreover, NEPA established a broad, national environmental protection framework.[2] The general regulations governing the implementation of NEPA, published by the Council on Environmental Quality (CEQ), are the most helpful elaboration on the bare requirements of the NEPA. These regulations are set forth in the Code of Federal Regulations, Parts 1500–1508.[3] Each federal agency also has its own regulations, which are typically published in the Code of Federal Regulations, or in their internal manuals. They describe in greater detail their policies for compliance with NEPA.[4]

Similarly, on March 21, 1971, the first federal environmental law in Mexico, the Federal Law for the Prevention and Control of Environmental Pollution,[5] was published in the Federal Official Gazette. Three *reglamentos*[6] (regulations) were enacted to implement this law: The Regulation to Prevent and Control Air Pollution; Regulation to Control Water Pollution; and Regulation to Prevent and Control Marine Pollution. In 1982, the Mexican Congress abrogated this law and enacted the Federal Law for the Protection of the Environment.[7] Subsequently, this second law was abrogated in 1988 by the LGEEPA.

The LGEEPA is the fundamental environmental law in Mexico. This law has been amended several times. It sets forth chapters on environmental impact permits and prevention and control of air and water pollution. It also provides enforcement procedures and other provisions concerning the respective responsibilities of the federal and state governments.[8] It is important to clarify that LGEEPA is not a federal law. It is a "general" law, which, according to Mexican law, means that it is a law applicable to all municipalities, states, and the nation.

NEPA requirements are invoked when proposals for airports, buildings, military complexes, highways, parkland purchases, and other federal activities take place. Similarly, prior to initiating operations in Mexico, several activities under federal jurisdiction, including petrochemical, mining, and electricity generation industries, as well as hazardous waste treatment and disposal activities, must obtain an Environmental Impact Authorization, according to LGEEPA.

Figure 1 shows a general overview of the U.S. executive branch structure. Figure 2 shows the Mexican executive branch structure. The figures identify the distribution of authorities charged directly or indirectly with managing the environmental affairs of each country.

NEPA requires that all federal agencies prepare an Environmental Impact Statement (EIS) on major federal projects that could significantly affect the quality of the environment. In contrast, according to the regulations of LGEEPA regarding environmental impact assessments, SEMARNAT is the only federal agency that has specific obligations and goals regarding environmental impact evaluations. For specific projects, obligations to other federal ministries and interested parties in Mexico regarding the environmental impact assessment are set forth in other laws and regulations. Table 1 summarizes various similarities and differences that exist between NEPA and LGEEPA.

Among the fundamental differences between the legal systems of Mexico and the United States, it is important to point out that Mexico is a civil law jurisdiction, while 49 states of the U.S. use the common law system.[9] The civil law system is predominantly based on statutes and enacted laws. In contrast, the U.S. common law system is based on case law, where judges set precedent for future cases.

The U.S. Constitution does not provide any explicit right related to the health of the environment.[10] In contrast, Article 4 of the Mexican Constitution states: "Every person has the right to health protection" as well as "the right to an environment adequate for their development and wellness." The Mexican Constitution states these rights expressly, probably because the Mexican legal system (civil law system) requires a significant level of written detail.[11]

Figure 1. U.S. Executive Branch Structure

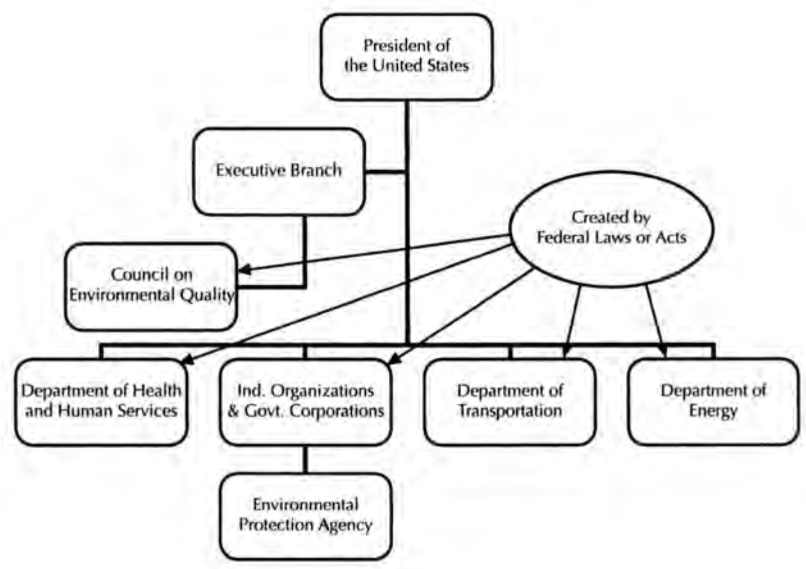
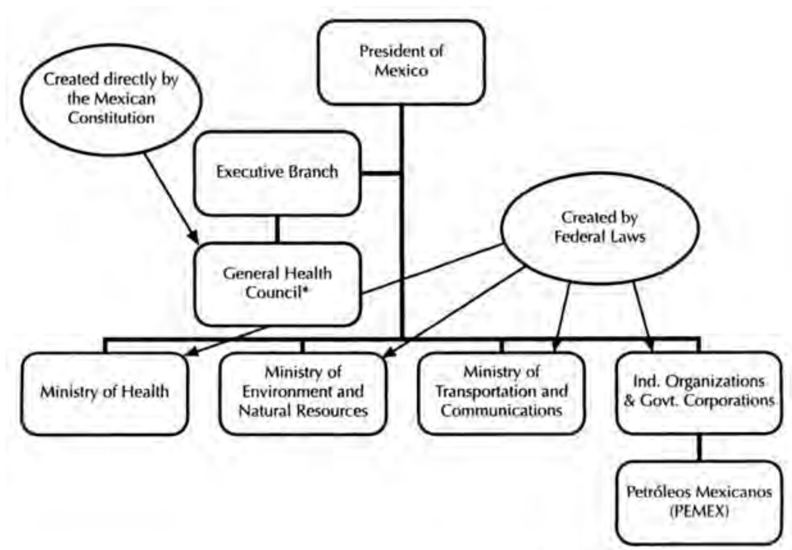


Figure 2. Mexican Executive Branch Structure



*In practice, the General Health Council is not relevant for the area of environmental impact affairs. The Ministry of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT) has the practical control of such issues.

Table 1. A Comparison of NEPA and LGEEPA

NEPA	LGEEPA
Recognition of the potential transboundary environmental impact of projects in the U.S. Executive Order 12114 (Environmental Effects Abroad); and the Guidance on NEPA Analyses for Transboundary Impacts.	**Recognition of the potential transboundary environmental impact of projects in Mexico.** SEMARNAT also recognizes it. Sections III and IV of Article 5 of the LGEEPA.
Notice of Intent. Brief notice issued by the "lead agency," which announces proposal action and possible alternatives, and other relevant information. Timeline for preparation of Notice of Intent: Variable.	**Preventive Notice.** "Project developer" (public or private investor) may request a ruling or submit a Preventive Notice (similar to the Notice of Intent) to SEMARNAT, in order to announce proposed action. Time for preparation: Variable.
Scoping process is started by the "lead agency." Average (desirable) time for scoping: 30–90 days. More time may indicate poor management by the lead agency.	**Scoping process.** SEMARNAT has 30 days to determine if a specific project requires the preparation of an Environmental Impact Manifest (EIM). Article 35 of the LGEEPA.
Drafting the environmental impact statement. "Lead agency" invests an average of 90–270 days preparing the Draft EIS. Once the document is prepared, the "lead agency" may spend between 30–90 additional days in internal revision (usual reason for delay). 40 CFR 1506.10 (c) and 40 CFR 1508.22.	**Drafting the environmental impact statement.** When an EIM authorization is required by SEMARNAT (or when it is voluntarily submitted to SEMARNAT by a project developer), the project developer is responsible for preparing this document. Once the project developer has submitted the EIM, SEMARNAT must issue a resolution within the next 60 days (under extraordinary circumstances, 120 days to issue a resolution is allowed). Article 35-BIS of the LGEEPA.

Table 1. *(continued)*

NEPA	LGEEPA
Scoping and public involvement in the United States. Draft EIS is circulated for public review for at least 45 days. The incorporation of agency comments is required within 15–45 days before filing the final EIS with EPA. Once the final EIS is submitted, the law allocates 30 days for a mandatory waiting period in order to make the Record of Decision available to the public for comment.* Sec. 101 [42 USC §4331], and Sec. 205 [42 USC §4345] of the NEPA.	**Scoping and public involvement in Mexico.** EIM filed by the project developer is circulated by SEMARNAT for public review. When a party requests SEMARNAT to conduct public consultation for the EIM that has been filed, SEMARNAT may start a public consultation period (20 days). In addition, SEMARNAT may request that the project developer publish part of the EIM filed in a newspaper. Once the abstract is published in the newspaper, people have 10 days to formally request SEMARNAT to provide public access to the entire EIM. When public health or the environment is potentially at significant risk due to the project, SEMARNAT may coordinate a public meeting with local authorities to discuss the project. Article 34 of the LGEEPA.
Possibility to perform binational environmental impact studies related to a proposed action. Section 2–3 of Executive Order 12114.	**Possibility to perform binational environmental impact studies related to a proposed action.** This possibility is not explicitly stated in the LGEEPA or in its regulations.

*Time estimation regarding the NEPA process was adapted from the original estimation prepared by Ray Clark (The Clark Group, LLC).

Transboundary Application of NEPA and LGEEPA: Existing Provisions that Promote Border Sustainability

International Law

In the United States, it has been customary law since the 1905 Trail Smelter Arbitration that no nation may undertake acts on its territory that will harm the territory of another state.[12] This rule of customary law has been recognized as binding in Principle 21 of the Stockholm Declaration on the Human Environment and Principle 2 of the 1992 Rio Declaration on Environment and Development. This concept, along with the duty to give notice to others to avoid or avert such harm, is incorporated into numerous treaty obligations undertaken by the United States. Analysis of transboundary impacts of federal agency actions that occur in the United States is an appropriate step toward implementing those principles.[13]

It is evident that there is a significant bilateral nature to many environmental issues between the United States and Mexico. In fact, both nations have executed several binational environmental agreements. However, none of these agreements has duly considered the environmental impact concerns in the U.S.-Mexican border region from a holistic perspective (socioeconomic impact, scoping and public involvement, environmental justice, science and technology implementation).

One of the consequences of the lack of such a holistic binational legal framework is the reduced potential to build major infrastructure projects sustainably in the U.S.-Mexican border region. However, this lack of a binational legal agreement should not be considered the only reason why NEPA and LGEEPA are perceived, sometimes, as barriers to the sustainable development of the U.S.-Mexican border. Other reasons for this will be discussed later.

When the governments of the United States, Canada, and Mexico entered into the North American Agreement on Environmental Cooperation (NAAEC), they made a firm commitment to create a North American Agreement on Transboundary Environmental Impact Assessment (NAATEIA). After 15 years, there remain few concrete signs of a NAATEIA being negotiated under the auspices of the Commission for Environmental Cooperation (CEC).[14] NAATEIA would require each country to assess actions or projects undertaken in its respective border regions for significant transboundary environmental impacts.[15] These negotiations require the three countries to develop an agreement to:

- Assess environmental impacts of proposed actions or projects in any of the three countries party to the North American Free Trade Agreement (NAFTA) that would likely cause significant adverse transboundary impacts within the jurisdiction of any of the other parties
- Develop a system of notification, consultation, and sharing of relevant information between countries with respect to such projects
- Consider measures to mitigate potential adverse effects of such projects

The negotiations relating to the Draft NAATEIA have remained in abeyance since 1998, despite the fact that the Joint Policy Advisory Committee has called on numerous occasions for a "reenergizing" of the negotiations[16] and, according to Jan Gilbreath of the U.S. EPA, some Mexican environmental officials have seemed willing to increase public involvement in management and discussion of transboundary issues. The parties had committed to negotiate a new NAATEIA by 2007, although to date no details of this initiative have been disclosed.[17] The NAATEIA would require federal authorities to notify their counterparts across the border of any project proposal they receive that has potential for a significant adverse environmental impact in the neighboring country. Authorities and citizens in the other country then would have a chance to provide input during the decision making about the expediency of granting the environmental authorization. If the NAATEIA is implemented, it will mark the first time NAFTA partners have had a positive influence in each other's granting of permits for projects affecting the environment.[18]

Parallel to the NAATEIA negotiations, Mexico and the United States have developed national provisions that allow their federal governments to investigate environmental impacts of infrastructure projects originating outside of their own borders. Those national provisions of Mexico and the U.S., which should be duly implemented as facilitators of the border sustainability, are described below.

Transboundary Applicability of LGEEPA

Section III of Article 5 of the LGEEPA states that it is the responsibility of the Federation to be aware of actions (projects) that originate outside of the country, but that affect the ecological equilibrium of the national territory. Moreover, Section IV of Article 5 of the LGEEPA considers that it is the responsibility of the Federation to be informed of actions (projects) originating within the country that have the potential to affect the ecological equilibrium of other country(ies). Both provisions place responsibility on the federal government of Mexico to address transboundary environmental impact concerns.

Section XVII of Article 15 of the LGEEPA establishes that the nation is interested in assuring that activities developed within the country do not damage the ecological equilibrium of foreign countries. The federal government must follow this as a principle for ecological preservation, restoration, and protection.

Transboundary Applicability of NEPA

Section 102(2)(C) of the NEPA requires federal agencies to assess the environmental impacts of and alternatives to proposed major federal actions that are likely to significantly affect the quality of the human environment. The U.S. Congress also recognized the "worldwide and long-range character of environmental problems" in NEPA and directed agencies to assist other countries in anticipating and preventing a decline in the quality of the world environment. Neither NEPA nor the CEQ regulations implementing the procedural provisions of NEPA define agencies' obligations to analyze effects of actions limited by jurisdictional boundaries. Rather, the entire body of the NEPA law directs federal agencies to analyze the effects of proposed actions to the extent that there are reasonably foreseeable consequences of the proposed action, regardless of where those impacts might occur. Agencies must analyze indirect effects caused by the action when such effects are reasonably foreseeable, including growth-inducing effects and related effects on the ecosystem, as well as cumulative effects.[19]

Executive Order 12114 (Environmental Effects Abroad)[20] of January 4, 1979, which appears in 44 FR 1957, 3 CFR, 1979 Comp., p. 356, unless otherwise noted, requires federal agencies to analyze possible significant impacts of proposed projects on the environment outside the United States, using the NEPA framework as the guideline. The purpose of this Executive Order is to enable responsible federal officials to have ultimate responsibility for authorizing and approving actions covered by this order, to be informed of pertinent environmental issues, and to take these issues under consideration in relation to other matters of national policy interest. While based on independent authority, this order promotes the NEPA and other laws[21] consistent with the foreign policy and national security policy of the U.S. This order also represents the United States government's exclusive and complete determination of procedural and other actions to be taken by federal agencies to further the purpose of the NEPA with respect to the environment outside the United States, its territories, and its possessions. The following types of documents are to be used in conjunction with actions described in this order (Section 2–3):

- Environmental impact statements (including generic, program, and specific statements)
- Bilateral or multilateral environmental studies, relevant or related to the proposed action, by the United States and one or more foreign nations, or by an international body or organization in which the United States is a member or participant
- Concise reviews of the environmental issues involved, including environmental assessments, summary environmental analyses, or other appropriate documents

The Border Environment Cooperation Commission (BECC)[22] fulfills an essential role in effectively applying binational policies and programs that support the sustainable development of environmental infrastructure in the border region. BECC applies the legal provisions described in NEPA regarding how to assess the environmental impacts of certain projects. The specific purpose of BECC is to certify environmental projects in order for them to receive funds from the North American Development Bank (NADB). As a result, NEPA is applied by BECC in the U.S. and in Mexico to "certify the technical feasibility and environmental health impacts of projects," as well as to "ensure transparency and promote community-based support for projects."[23]

Additionally, the U.S. section of the International Boundary and Water Commission (IBWC) has been the lead agency during certain NEPA processes. However, there is no evidence that the Mexican section of the IBWC has been formally included in such legal processes. It is relevant to mention that no other binational or Mexican governmental authority utilizes the NEPA principles in the U.S.-Mexican border region on a regular basis. In addition, neither BECC nor any other U.S. agency expressly reviews or considers the LGEEPA principles for those projects located in the U.S.-Mexican border region. Therefore, proper interpretation and application of the transboundary provisions contained in the LGEEPA and the NEPA are recommended.

The NAATEIA could provide clarification to Mexico and the United States regarding how to apply NEPA and LGEEPA transboundary provisions in a coordinated and equitable way. Within the context of negotiations undertaken among the three North American governments (Canada, United States, and Mexico), on July 1, 1997, the CEQ issued the "Guidance on NEPA Analyses for Transboundary Impacts." The purpose of this guide is to clarify the applicability of the NEPA regarding those proposed federal actions in the United States that may have effects extending across the border and affecting another country's environment. While the guidelines arise in the context of negotiations undertaken by these three governments in connection with the NAATEIA, the regulations issued by CEQ pertain to all U.S. federal actions that are normally subject to NEPA, whether covered by an international agreement or not.[24]

In the context of international agreements, the parties may establish a specific process for obtaining information from the affected country that could then be relied upon in most circumstances to satisfy agencies' responsibility to undertake a reasonable search for information. It is important to identify the matters to which this guidance is applied and those to which it is not.[25]

The CEQ noted that many proposed federal actions will not have transboundary effects, and federal agencies should use the scoping process to identify such actions. For those actions that have the potential to cause transboundary impacts, case law interpreting NEPA has reinforced the need to analyze these impacts regardless of geographic boundaries. The CEQ concludes, "NEPA requires agencies to include analysis of reasonably foreseeable transboundary effects of proposed actions in their analysis of proposed actions in the United States. Such effects are best identified during the scoping stage and should be analyzed to the best of the agency's ability using reasonably available information. Such analysis should be included in the Environmental Assessment (EA) or EIS prepared for the proposed action."[26]

How are NEPA and LGEEPA Applied in the U.S.-Mexican Border Region?

NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions. Two major purposes of the environmental review process are to promote better informed decision making and citizen involvement, both of which lead to implementation of NEPA's policies.[27]

Section 2–3 of Executive Order 12114 lists actions that shall be taken into consideration by agencies: (1) major federal actions that significantly affect the environment of the global commons outside the jurisdiction of any nation; (2) major federal actions that significantly affect the environment of a foreign nation not participating with the United States and not otherwise involved in the action; (3) major federal actions that significantly affect the environment of a foreign nation and generate in that nation (*a*) a source that produces emissions or pollutants that are prohibited or strictly regulated by federal law in the U.S. because of a serious public health risk, or (*b*) a physical project that in the United States is prohibited or strictly regulated by federal law to protect the environment against radioactive substances; and (4) major federal actions outside the United States, its territories, and its possessions that significantly affect natural or ecological resources of global importance designated for protection under this subsection by the President or, in the case of such a resource protected by international agreement binding on the United States, by the Secretary of State.

Notwithstanding Section 2–3, several actions are exempt from such executive orders, including, for example: (1) actions not having a significant effect on the environment outside the United States as determined by the agency; and (2) actions taken by or pursuant to the direction of the President or cabinet officer when national security is involved, or when the action occurs in the course of an armed conflict.

NEPA has been applied in the U.S.-Canadian border region more effectively than in the U.S.-Mexican border region. Such inequity adversely affects the sustainability of the U.S.-Mexican border by comparison. Case law interpreting NEPA (in the U.S.-Canadian border area) has reinforced the need to analyze impacts regardless of geographic boundaries of the United States, and has also assumed that NEPA requires analysis of major federal actions that take place entirely outside of the United States, but could have environmental effects within the United States. Specifically, in *Swinomish Tribal Community v. Federal Energy Regulatory Commission* (FERC), Canadian interveners were allowed to challenge the adequacy of an EIS prepared by the U.S. FERC in connection with its approval of an amendment to the city of Seattle's license that permitted raising the height of the Ross Dam on the Skagit River in the state of Washington. Assuming that NEPA required consideration of Canadian impacts, the court concluded that the report had taken the requisite "hard look" at Canadian impacts. Similarly, in *Wilderness Society v. Morton*, the court granted intervener status to Canadian environmental organizations that were challenging the adequacy of the trans-Alaska pipeline EIS.[28] The court granted intervener status because it found that there was a reasonable possibility that oil-spill damage could significantly affect Canadian resources, and that Canadian interests were not adequately represented by other parties in the case. In sum, based on legal and policy considerations, CEQ has determined that agencies must include analysis of reasonably foreseeable transboundary effects of proposed actions in their analysis of proposed actions in the United States.[29]

One difference between Canada and Mexico is that Canada has provisions for a participant funding program to help individuals and organizations involve themselves in public reviews of projects.[30] Above all, however, the strength of the legal system in favor of protecting the environment and ecosystems located in the border areas depends on the base of public environmental concern and vigilance.

The Reduced Success of the NEPA and LGEEPA as Promoters of Border Sustainability

Creation and Application of the Laws

In theory, the requirements of NEPA[31] and LGEEPA[32] are relatively straightforward. NEPA and LGEEPA are in continuity with policies of both federal governments and encourage the use of all practicable means to create and maintain conditions in which both humans and nature can exist in productive harmony. However, there is currently an ongoing debate, mainly in the U.S., about the efficiency and effectiveness of NEPA. The perception of the effectiveness and efficiency of the environmental impact provisions encompassed within LGEEPA in Mexico is not much better than the perception of NEPA in the U.S. This debate stems from commonly held perceptions that (1) NEPA requires extensive resources; (2) the time and costs of these laws are inappropriate; and (3) NEPA and LGEEPA seldom affect actual decision making because the quality of a LGEEPA or NEPA analysis is adversely affected by a lack of resources (economic and human) and time.[33]

On June 7, 1988, SEMARNAT published the regulations for LGEEPA regarding environmental impact assessments, but due to efficiency and effectiveness concerns, SEMARNAT published new regulations on May 30, 2000. However, the applicability of these new regulations for LGEEPA is still problematic, because these new regulations grant excessive power of discretion to the federal government regarding how to coordinate public involvement.

The implementation of NAATEIA could increase the communication level between Mexico and the United States for the development of environmental impact analyses. However, if the original spirit of the NEPA and LGEEPA is not adhered to, such international agreements will have almost no effectiveness. Discretionary power granted in favor of national authorities in Mexico and the U.S. regarding how to apply these relevant laws might be a barrier to the sustainable development of the U.S.-Mexican border region. Appendix A includes two petitions filed by citizens of the U.S.-Mexican border with the Commission for

Environmental Cooperation (CEC), arguing that both federal governments abused their discretionary power during the application of environmental impact laws in Arizona and Baja California.

Another important reason why neither NEPA nor LGEEPA has succeeded in fulfilling its sustainable development objectives is that the regulations to implement these statutes are almost exclusively limited to one small portion of the law. Conscientious consideration of the environment remains critically important when decisions are made that could affect it, but LGEEPA and NEPA have limits:

- Regulations of LGEEPA in the area of environmental impact assessment procedure are limited to analyzing and authorizing projects under federal jurisdiction
- NEPA is largely limited to analyzing project-level environmental impacts of federally sponsored projects, but it has the potential to help local governments and citizens contemplate what social, economic, or infrastructure development should take place in a region over time[34]

Environmental issues identified can often be mitigated through application of alternative methods for achieving the same project objective. NEPA, LGEEPA, and LGEEPA regulations require the development of alternatives for project aspects that are likely to cause significant environmental impacts. Therefore, in theory, if decision makers were presented with an array of choices and explicit tradeoffs, they would be more likely to choose the environmentally preferable path, provided that it does not hamper the ability to execute their mission. If appropriately used, NEPA and LGEEPA incorporate discipline, logic, and information into the decision-making process, creating a framework with specific milestones and publicly available information. Unfortunately, many government officials from the U.S. and Mexico, as well as private and public developers who file project proposals, retain the ultimate power to make the final decision and may not truly prefer the most sustainable option. As long as it is demonstrated that the potential environmental impacts have been thoroughly reviewed and considered, the most sustainable path is not required to be selected. This discretionary power is defined by the internal legal systems in force in Mexico and in the United States.[35] Such power has been supported in numerous instances of case law in both countries. However, the courts have required that decision makers strictly adhere to procedural matters relating to the NEPA and LGEEPA processes. As a result, most successful claims against federal agencies under NEPA and LGEEPA have been based on such identified procedural shortcomings. Documents thus become more important than analysis and decision-making processes.[36] One way to improve awareness of these laws and public participation is to enhance consultation with representatives of science, industry, agriculture, labor, conservation organizations, state and local governments, and others.[37]

While Mexican and U.S. environmental laws and practices provide some support for sustainability in the border region, numerous barriers frustrate coordinated and cooperative efforts. Some of the most significant barriers to sustainability include the following:

Barrier #1: U.S. and Mexican federal, state, and local governments often have different interests that result in different priorities. Moreover, there is no direct link in the United States between the binational planning process and the federal budget process. Thus, even when U.S. and Mexican interests coincide and officials responsible for border planning can agree on a project, the United States or Mexico may not be able to fund and implement the proposed action. It is essential that all processes (federal, state, local) operate in conjunction with one another to avoid the development of unsustainable projects or inaction when action is required. For example, at the March 2004 meeting of the Binational Group on Bridges and Border Crossings, U.S. and Mexican officials agreed to assign top priority to the new San Luis II crossing on the Arizona-Sonora border, with the goal of opening the new port of entry in late 2007 or early 2008. Based on this agreement, in December 2004, Mexico launched a process to identify a concessionaire to build its facilities. However, the U.S. President's FY–06 budget proposal to Congress did not include the project.[38]

Barrier #2: Inadequate funding for binational projects that could facilitate sustainability in the U.S.-Mexican border. In 2000, the Border Trade Alliance (BTA), a prominent private-sector organization promoting commerce between the United States and its neighbors, worked with U.S. federal inspection agencies and the U.S. General Services Administration to produce an assessment of border infrastructure deficiencies. The resulting report, based on an official assessment of these needs, revealed that nearly $460 million were needed for infrastructure at the southern border of the U.S. Although the terrorist attacks of 9/11 focused attention on the urgency of improving homeland security—including improvements at the ports of entry—new resources have been directed primarily to the northern U.S. border with Canada.[39]

Barrier #3: Timing for the development of binational projects is not standardized. Proposals related to ports of entry, for example, have been affected by this barrier.

Barrier #4: Public involvement (based on environmental justice principles) and the scoping process are not adequate enough. Information is not commonly made available to the public or interested parties in an unambiguous manner. Moreover, inefficient scoping is evident when an issue is "overstudied." In both scenarios, public and decision-maker perceptions of the process are negatively affected. As a result, agencies and project developers try to avoid LGEEPA or NEPA applicability rather than embrace either as a valuable tool.

Barrier #5: Excessive discretionary power granted to Mexican and U.S. governmental authorities. It is recommended to reduce and redistribute such power in Mexico in order to increase transparency and maintain public involvement once the EIM is filed with SEMARNAT by the project developer. This recommendation could be implemented by amending the LGEEPA. Moreover, it is also advisable to reduce discretionary power in the United States regarding what projects might be exempted from completing an EIS due to national security or other reasons.

Barrier #6: An EIA in the U.S. and an EIM in Mexico generally do not consider all transboundary environmental impacts. Environmental impacts of buildings, for example, occur throughout all life stages of a building. This includes site selection, design, location, construction, use, renovation, and demolition. Direct environmental impacts that result from the construction and operation of buildings include greenhouse gases and other air emissions related to energy use, water use and discharge, storm water runoff, impact related to building materials, solid waste from various stages of a building's life, and indoor air quality. For further information, see Appendix B. Secondary impacts are generally associated with building product life cycles, infrastructure development, and transportation systems.[40] Transboundary environmental impacts related to building projects under the LGEEPA or NEPA process should be developed using green building criteria in order to minimize trans-boundary environmental impacts during the life cycle of the project.

Barrier #7: Cumulative effects of population growth and socio-economic impact analyses are not sufficiently considered in an EIM or EIS. Population growth is rising at unsustainable rates in many parts of the U.S.-Mexican border region. According to the Center for Strategic and International Studies (CSIS), by 2030 the population in the Paso del Norte region will increase dramatically; the population of the city of El Paso, Texas, doubles every 25 years. Other subbasin areas in the U.S.-Mexican border region are also experiencing rapid population growth. According to the CSIS, efforts should be undertaken to discourage population growth in areas that do not have a sufficient local water supply to meet the needs of their respective populations.[41]

Barrier #8: More capacity building is required. Although the body of LGEEPA and NEPA expertise has grown, there is still an insufficient pool of skilled, available professionals. Additionally, agencies and ministries often do not assign their most effective and efficient personnel to environmental impact tasks. Even though the head of the agency or ministry may be deeply involved in the trade-offs and decisions affecting a proposal, he/she may be largely absent from the LGEEPA or NEPA processes.[42]

Most of the aforementioned barriers could be remedied by modifying the implementation of NEPA and LGEEPA without changing the laws. However, even though NEPA and LGEEPA eloquently articulate national sustainable development policies and provide ways to implement them in the United States and Mexico, there are at least two significant reasons why NEPA or LGEEPA cannot serve as a nation's only road map to a sustainable society:

- Neither NEPA nor LGEEPA addresses social inequity and poverty. NEPA and LGEEPA must be implemented to work with other policies and social institutions that together will fix these gaps
- NEPA and LGEEPA have limitations as tools for sustainable development due to intermittent utilization and enforcement. If these policies were adhered to and CEQ and SEMARNAT used their authority to see that all sections of the statutes were

implemented, NEPA and LGEEPA would more than adequately provide a comprehensive, binational framework for sustainable development at the U.S.-Mexican border[43]

How to Increase NEPA's and LGEEPA's Efficiency and Effectiveness in the U.S.-Mexican Border Region: Recommendations for a Sustainable Scenario in 2030

LGEEPA and NEPA have the capacity to be tools for achieving a sustainable border region in 2030 if their principles are applied in a deliberate process of integration for both urbanization and ecology. Doing so will mean encouraging citizens, specialists, lawyers, and leaders to utilize the interdisciplinary approaches employed by other stakeholder groups for better, more comprehensive regional planning.[44] Table 2 provides 10 recommendations to help reduce current barriers to sustainability that are exacerbated by the inadequate implementation of the LGEEPA and NEPA processes.

Table 2. Recommendations for Improving Sustainability in the U.S.-Mexican Border Region using NEPA and LGEEPA

Recommendation	Is this recommendation applicable to both countries?
1. Make the process more transparent and simple.	✓ Yes
2. Reduce the influence of single-purpose players and increase awareness of environmental justice affairs, including tribal and *ejido* consultation and involvement.[45]	✓ Yes
3. Increase law enforcement and vigilance.	✓ Yes
4. Consider greenhouse gas emissions and climate change in the environmental impact analysis.	✓ Yes
5. Successfully conclude negotiations to create NAATEIA.	✓ Yes
6. Establish more public-private partnerships to increase both funding and staffing levels.	✓ Yes

Table 2. *(continued)*

Recommendation	Is this recommendation applicable to both countries?
7. Better use emerging technologies, including developing a system to predict environmental effects caused by cumulative effects.	✓ Yes
8. Develop public policies to improve population growth control based on socioeconomic impact analysis.[46]	✓ Yes
9. Undertake border security efforts with recognition of the need to protect cultural and natural resources.[47] In fact, the Security and Prosperity Partnership (SPP) of North America was created in 2005 to advance the common security and prosperity of the United States, Canada, and Mexico. To meet the SPP goal, the partners work to expand cooperation and harmonization of immigration, border, and security policies. SPP's environmental agenda calls for improving air quality, enhancing water quality, and protecting biodiversity.[48] SPP intentions should be considered and reinforced in LGEEPA and NEPA processes.	✓ Yes
10. Require "green building": All governmental building projects should be certified by the Green Building Rating System or another equivalent organization. There should be a mechanism to offer fast-track permitting for green building in the U.S.-Mexican border region. Actually, in 2005 the American Institute of Architects (AIA) issued The 2030 Challenge, which establishes a target and schedule to be achieved with carbon-neutral buildings by 2030 using non-fossil fuel energy to operate. In addition, some cities such as Santa Fe, NM, have adopted it as law.[49]	✓ Yes

Source: Author.

ENDNOTES

[1] Ray Clark and Larry Canter, *Environmental Policy and NEPA: Past, Present and Future* (Boca Raton, FL: St. Lucie Press, 1997); P. Offringa, "Creating a User-Friendly NEPA." Pp. 289–298 in *Environmental Policy and NEPA: Past, Present and Future*, R. Clark and L. Canter, eds., 1997.
[2] U.S.EPA. "Summary of the NEPA." http://www.epa.gov/lawsregs/laws/nepa.html.
[3] NEPA is codified in 42 U.S.C. §§4321–4370.
[4] Robert V. Percival, et al., *Environmental Regulation: Law, Science, and Policy* (Boston: Little, Brown and Co., 1996) 1108.
[5] *Ley Federal para Prevenir y Controlar la Contaminación Ambiental*, in Spanish.
[6] *Reglamentos* are mandatory provisions to detail how to implement a specific law.
[7] *Ley Federal de Protección del Ambiente*, in Spanish.
[8] Baker & McKenzie Abogados, S.C. *Doing Business in Mexico*, 2006, p. 30.
[9] The exception is Louisiana, which uses the civil code.
[10] Percival et al. 1996.
[11] For example, in Mexico it is forbidden by Article 14 of the Mexican Constitution to solve criminal cases using criteria that are not expressly stated on the corresponding Criminal Code. Such Article means it is mandatory to comply strictly with the wording of the law.
[12] *Trail Smelter Arbitration*, U.S. v. Canada, 3 UN Rep. Int'l Arbit. Awards 1911 (1941). The case involved a smelter in British Columbia that was causing environmental harm in the state of Washington. See: American Law Institute's Restatement of the Foreign Relations Law of the United States 3d, Section 601, ("State obligations with respect to environment of other States and the common environment").
[13] CEQ, "Guidance on NEPA Analyses for Transboundary Impacts." July 1, 1997. http://www.gc.noaa.gov/documents/transguide.pdf.

[14] Alastair Neil Craik, "Transboundary Environmental Impact Assessment in North America: Obstacles and Opportunities." In *Theory and Practice of Transboundary Environmental Impact Assessment*, Kees Bastmeijer and Timo Koivurova, eds. (Martinus Nijhoff, 2008), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1285509.
[15] http://www.mms.gov/eppd/compliance/nepa/procedures/trans/index.htm.
[16] Stephen Siciliano, "Nafta United Urges North America to Step up Transborder EIA Negotiations." *International Environmental Daily* (17 December 2002), http://international.westlaw.com (BNA International Environment Daily).
[17] Craik 2008.
[18] Jan Gilbreath, *The Environment and Trade: Predicting a Course for the Western Hemisphere Using the North American Experience* (Washington, D.C.: Center for Strategic and International Studies, 2001) 16.
[19] CEQ 1997.
[20] http://www.archives.gov/federal-register/codification/executive-order/12114.html.
[21] Marine Protection Research and Sanctuaries Act and the Deepwater Port Act.
[22] "The Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB) were created in 1993 under a side agreement to the NAFTA for the purpose of enhancing the environmental conditions of the U.S.-Mexican border region and advancing the well-being of residents in both nations." http://www.cocef.org/english/index.html.
[23] http://www.cocef.org/english/index.html.
[24] CEQ 1997.
[25] CEQ 1997.
[26] http://www.mms.gov/eppd/compliance/nepa/procedures/trans/index.htm.
[27] http://www.nepa.gov/nepa/Citizens_Guide_Dec07.pdf.
[28] *Northern Alaska Environmental Center v. Lujan*, 961 F.2d 886, 890 (9th Cir. 1992).
[29] CEQ 1997.
[30] Clark and Canter, p. 100.
[31] Offringa, p. 290.

[32] Regulations to the LGEEPA in the Area of Environmental Impact published in the Federal Official Gazette on May 30, 2000.
[33] R. Webster, "Increasing the Efficiency and Effectiveness of NEPA through the Use of Technology." In *Environmental Policy and NEPA: Past, Present and Future*, R. Clark and L. Canter, eds., 1997, pp. 215 and 226.
[34] H. Kaufman, "The Role of NEPA in Sustainable Development." In *Environmental Policy and NEPA: Past, Present and Future*, R. Clark and L. Canter, eds., 1997, p. 315.
[35] A Mexican court issued a resolution regarding the limits of SEMARNAT's discretionary power during the application of provisions stated by the LGEEPA in the area of environmental impact. Location: 9th Period; T.C.C.; S.J.F. and its Gazette; XXII, July, 2005; p. 1441; [Isolated Criteria of the Court – *Tesis Aislada*].
[36] Offringa, pp. 290–293.
[37] Kaufman, pp. 316 and 317.
[38] Ninth Report of the Good Neighbor Environmental Board to the President and Congress of the United States (Washington, D.C.: EPA and OCEM, 2006) 10–11.
[39] Ninth Report of the Good Neighbor Environmental Board, pp. 12–13.
[40] CEC, *Green Building in North America: Opportunities and Challenges* (Montreal: CEC, 2008) 22 and 23.
[41] CSIS, *U.S.-Mexico Transboundary Water Management: The Case of the Rio Grande / Rio Bravo. Recommendations for Policymakers for the Medium and Long Term.* A Report of the U.S.-Mexico Binational Council (Washington, D.C.: CSIS, 2003) 17.
[42] Clark and Canter 1997; Offringa, p. 295.
[43] Kaufman, pp. 318 and 319.
[44] A. F. Euston, "NEPA's interdisciplinary mandate: redirection for sustainability." In *Environmental Policy and NEPA: Past, Present and Future,* R. Clark and L. Canter, eds., 1997, p 321.
[45] Kaufman, p. 318.
[46] Education programs, incentives to small families, and so forth.
[47] Ninth Report of the Good Neighbor Environmental Board, p. iii.
[48] www.spp.gov.
[49] CEC, p. 37; www.architecture2030.org.

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APPENDIX A

ID Number	Petition (Case)	Date of Petition	Party	Status of the Process
SEM–96–004 / The Southwest Center for Biological Diversity and others	Petitioners argued that the United States is failing to administer the effective application of its environmental laws, specifically the NEPA, in connection with the U.S. Army operations in Fort Huachuca, Arizona.	November 14, 1996	United States	Process concluded because the petitioners gave up on June 5, 1997.
SEM–98–007/ Environmental Health Coalition and others	Petitioners declared that Mexico breached environmental laws in Tijuana, Baja California. Case: An abandoned lead smelter that represented a high health risk to neighboring communities and the environment.	October 23, 1998	Mexico	On May 16, 2000, the Council decided by unanimity to request to the Secretariat the elaboration of a Fact File.*

*CEC. "Lecciones aprendidas: Peticiones ciudadanas relativas a los artículos 14 y 15 del ACCAN." 2001.

Appendix B

Responsibility of Buildings	Percentage in the United States	Percentage in Mexico	Percentage of Average Reduction in Green Building
All energy used in the country	40	17	30
All electricity used in the country	68	25	Not available
All carbon dioxide emissions	38	20	35
All potable water consumption	12	5	30–50
All waste generated	60	20	50–90*

*CEC. "Green Building in North America: Opportunities and Challenges." 2008.

XV

Financing Border Environmental Infrastructure: Where are We? Where to from Here?

Salvador Espinosa P.

ABSTRACT

Few would question the pressing need for adequate environmental infrastructure along the U.S.-Mexican border, but there are significant challenges involved. These include quantifying the amount of required investment and obtaining the funding for projects that often call for sizeable upfront disbursements. Increasing budgetary constraints in both countries make it necessary to think about innovative strategies to attract investment to the region. The aim of this paper is to invite scholars and policymakers to "think outside the box" and discuss alternative measures to channel financial resources to the region. This document addresses the issue in three steps. First, it provides readers with a brief overview of some of the mechanisms that could be used to finance environmental infrastructure, along with their advantages and limitations. Second, it presents preliminary estimates of investment needs and explains the way in which the public sector participates in infrastructure financing. Third, the paper explains some of the ways in which the private sector can participate and presents readers with a thought-provoking idea: the creation of a binational model of debt financing to bridge the gap between border environmental infrastructure needs and available funds.

INTRODUCTION

The challenges that the border region faces in terms of financing environmental infrastructure is of great relevance. Despite growing concerns about environmental preservation, the global economic slowdown has limited the financial capacity of governments and has introduced tighter budgetary constraints. The problem would not be that worrisome if it were not for the fact that the public sector is usually an important contributor of funds for environmental infrastructure. While the need for environmental preservation at the border region is evident, many of the required projects have high upfront costs that governments are finding difficult to cover. The challenge for policymakers interested in the U.S.-Mexican border is not a simple one: to narrow a growing deficit in environmental infrastructure at a time when the funding capabilities of the public sector have been curtailed.

The scarcity of government funds is not the only problem. Rapid population growth, industrialization, the creation of physical barriers, and other natural phenomena are depleting essential resources, putting economic development and even the security of the two nations at peril. A good example is water, which remains as one of the most pressing environmental problems faced by the border region. As a recent analysis illustrates, water scarcity constitutes a threat to the quality of life of border communities, endangers water-sensitive ecosystems, puts economic growth at risk, and strains diplomatic relations (Woodrow Wilson Center and COLEF 2009). Yet, the availability of government funds to deal with this sensitive policy issue has been constantly diminishing. According to a report by the Border Environment Cooperation Commission (BECC), as of fiscal year 2008, the required investment for border region water and wastewater infrastructure alone was $1 billion. Budget appropriations from the U.S. Congress for the U.S.-Mexico Border Program for that year were only $10 million.[1] This amount was enough to cover only 5% of the documented needs (BECC 2007). This gives a clear idea of the challenges that Mexico and the United States face in terms of border infrastructure financing. Bridging the gap between infrastructure needs and available funds can only be done if new and innovative financing mechanisms are designed. But most importantly, it can only be done if policymakers, government officials, and border residents are aware of the consequences that a lack of action would entail. The question is, then, how can funds be obtained to cover the cost of essential and much needed environmental infrastructure?

Christopher Erickson and David Eaton reflected on the same issue in 2002 when they reviewed five funding mechanisms that could be used to pay for environmental infrastructure projects: philanthropy, tax financing, user fees, contracting with the private sector, or bond markets (Erickson and Eaton 2002). Although they did not analyze the mechanisms in detail, their work gives a good idea of some of the existing policy alternatives for the financing of environmental infrastructure. For these authors, philanthropy could be an important source of funds for community projects with an environmental impact. This source of funds could certainly be useful for small-scale projects.

But while philanthropic organizations are very active in some regions, their funding capacity is still very limited. This is particularly noticeable in Mexico as a survey from the Border Philanthropic Partnership explains: "For the vast majority of companies operating *maquiladoras* along Mexico's northern border, charitable giving is substantially lower in Mexican border communities when compared to contributions made to comparable nonprofits in the United States. Of the companies surveyed, 65.5% contributed $10,000 or less in cash donations to charitable causes annually, and 25.5% contributed nothing to charities along the border where they operated. A mere 9.1% gave over $10,000 annually" (Kiy et al. 2005). Clearly, this alternative would not be an effective tool to channel the required flows of investment to the region.

Taxation is another option to try to gather needed funds. A funding model that is based on taxes, however, has two important limitations. The first limitation relates to the amount of resources that governments can obtain from taxes and the amount of resources that are needed to build large-scale infrastructure projects. The financial requirements of many border projects could hardly be covered with state or local tax proceeds from a single fiscal year. Even if it were possible, one must consider the fact that the spending of those tax revenues must be approved during annual budget negotiations where numerous agencies compete. And while border environmental infrastructure is important, it may not rank high on the list of priorities of a federal, state, or local government.

The second limitation of a taxation-based model of financing arises when there are different levels of government interacting in the border region (communities, cities, municipalities, counties, special districts, tribes, and state and federal governments). In many cases, these jurisdictions have overlapping or loosely defined roles and responsibilities. If the scope of their mandate is not that clear, the inevitable question is, who should pay for what? (i.e., which level of government should impose the tax?). If the geographical benefits of infrastructure projects are essentially local, one argument could be that the residents of that jurisdiction should bear a higher burden of the cost. But if a project is located in the vicinity of the international border, some may argue that the federal government should play a significant role in its financing. Notice, however, that even if border communities and local governments want to develop environmental infrastructure, their financial capabilities are limited. This is one of the reasons why higher levels of government (mostly federal) need to step up and provide the financial means to supply environmental infrastructure services that, in theory, should be paid for by local governments.

Erickson and Eaton (2002) also mention the possibility of charging fees to the users of an infrastructure project.[2] Although the authors do not discuss advantages and disadvantages, they argue that this is often an inadequate funding method for environmental infrastructure. The reason they cite is the difficulty of collecting user fees in many border communities. Although this is true in many sectors (they specifically address the case of water charges), one cannot assume that a similar situation will occur for every infrastructure project. Financial planners need to evaluate the feasibility of a user-charge scheme on a project-by-project basis.

Regardless of the advantages and shortcomings of particular tax and user-charge mechanisms, these possibilities cannot be analyzed without paying close attention to the prevailing economic and political context in each country. Many of the assessments and claims that Erickson and Eaton made eight years ago are still valid today. However, it is clear that the economic context is very different. This paper is being written when the international community is going through one of the worst economic downturns since the Great Depression of 1929. The recession has affected governments in Mexico and the United States in different ways. But even if the circumstances in each country vary, both governments must deal with shrinking tax bases and an increasing unwillingness from voters to accept higher taxes or service charges.

Policymakers need to find other mechanisms to pay for environmental infrastructure. Certainly, one possibility is to involve the private sector. In principle, two alternatives exist: agreements between the public and the private sectors (commonly known as public-private partnerships or PPP), or public sector borrowing.

Private-public partnerships are long-term contracts by which a private investor agrees to participate in the design, construction, and operation of public infrastructure in exchange for payments from the user of the facility or from the government that assigns the project. In many countries, such contracts are seen as an effective tool to obtain the funding that a government cannot secure through its normal budgetary process. But as Yescombe (2007) explains, while a PPP can accelerate infrastructure investment and overcome the limitations associated with public-sector provision, "[p]rivate-sector finance for a PPP clearly costs more than if the project were procured in the public sector and financed with public sector borrowing."

If infrastructure planners want to explore less expensive funding alternatives, accessing debt markets could be a cost-effective option. In doing so, border governments (or other project sponsors) would try to gather funds from individual and corporate investors interested in placing their savings in profitable projects. There are various mechanisms to attain this goal. The following discussion pays close attention to the opportunities that a bond market could offer.[3] When Erickson and Eaton wrote their essay in 2002, they affirmed that it was the right time for the development of a municipal bond market in Mexico (municipal debt markets have been operating in the United States for a long time). Their claim is still a valid one, with a small variation: if one takes into account that the benefits (or costs) of many environmental projects are not constrained to one side of the border, thinking about funding models that do not incorporate both countries no longer seems adequate. It is time to change the existing paradigm and address the infrastructure finance problem from a binational perspective. This will be the premise for the discussion that follows.

ENVIRONMENTAL INFRASTRUCTURE IN THE U.S.-MEXICAN BORDER: WHERE ARE WE?

Investment Needs: How Much Money are We Talking About?

For the purposes of this paper, the U.S.-Mexican border region is defined as the territory that is comprised of a 100-km (62-mile) wide strip on the U.S. side of the international border and a 300-km (186-mile) strip on the Mexican side. Environmental infrastructure will be defined as those projects "that will prevent, control, or reduce environmental pollutants or contaminants, improve the drinking water supply, or protect flora and fauna so as to improve human health, promote sustainable development, or contribute to a higher quality of life." These definitions are used by the governments of Mexico and the United States for designing public policies (Mexico and United States 2004). While the spatial definition serves to determine the geographical area where border infrastructure shall be built, the latter definition serves as a reference point to determine policy priorities and to quantify the investment needs for the border region (see Table 1).

Table 1. North American Development Bank's (NADB) Classification of Border Environmental Infrastructure

Priorities	• Water Supply
	• Water Conservation
	• Wastewater Treatment
	• Municipal Solid Waste
Expanded Mandate	• Air Quality Improvement
	• Clean and Renewable Energy
	• Energy Efficiency
	• Industrial and Hazardous Waste
	• Public Transportation

Source: NADB.

A crucial question needs to be asked at this point: How significant are the funding requirements for the region? The numbers vary among sources. In 2000, the Southwest Center for Environmental

Research and Policy estimated that the amount to meet the requirements for potable water, wastewater treatment, and solid waste disposal would be $3.2 billion and that 77% of this amount would be for wastewater treatment plants (GAO 2000). This figure still gives a reasonable idea of the massive amount of financial resources that must be channeled to the border region for environmental infrastructure, as well as the areas that are deemed as priorities. More recently, BECC estimated that investment requirements along the Mexican border are approximately $903 million (BECC 2008).[4] While efforts to quantify investment needs on the U.S. side are ongoing, a needs assessment for New Mexico gives an idea of infrastructure needs north of the international line. In New Mexico alone, the short-term investment needs are $554 million for drinking water, wastewater, and wastewater treatment; $5 million for solid waste disposal; and $500 million for paving rural roads (BECC 2009).

Evidently, further discussion is needed on the methods used to compute these figures and the amounts reported. But even if the numbers change, the core challenge remains the same: finding the financial resources to pay for these projects. What are the options?

Government Funding: When the Means are Not Enough to Meet the Ends

Large-scale environmental infrastructure projects, such as those listed in Table 1, have traditionally been funded with public monies. In general terms, this occurs for three reasons: because the good or service to be provided has the characteristics of a public good, making it unattractive to private investors;[5] because there are laws or regulations that prohibit or limit private investments; or because even if a specific infrastructure project has low profit potential, it might be highly desirable from a social or environmental standpoint.

In the United States, there are various agencies involved in environmental infrastructure financing. At the federal level, the Environmental Protection Agency (EPA) remains as one of the top contributors based on the total value of grants devoted to border environmental infrastructure projects. In the case of Mexico, a significant portion of federal funds is appropriated through programs administered by the Ministry of Environment and Natural Resources

(Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT). However, these federal agencies can only provide the funding that their respective legislatures authorize during the annual budget process.[6] Unfortunately, as evidence shows, the tendency has been toward a decrease in the appropriations for programs to finance environmental infrastructure. An illustrative example of the declining trend observed in government funding is the money appropriated by the U.S. Congress for the U.S.-Mexico Border Program, which constitutes one of the main sources of funding for water and wastewater projects. As data from BECC reveal, appropriations for this program have gone from $100 million in the mid-1990s to roughly $10 million in fiscal year 2008 (BECC 2007).

There are two important factors that need to be taken into account when assessing reductions in budget appropriations. The first factor has to do with the ongoing economic recession, its effects on government budgets, and the realignment of policy priorities that this situation requires. Countries around the globe are experiencing the consequences of an economic slowdown that has significantly affected revenue collections. Expenditure trends, nonetheless, continue showing an upward trend. This is putting additional pressures on public budgets and is forcing governments to rethink expenditure priorities. The second factor has to do with the process that must be followed to allocate government funds. Budget appropriations are the result of difficult and complex negotiations among actors who represent constituencies from numerous geographical areas and with a wide array of interests and policy agendas. These actors must compete for an increasingly limited amount of government revenues. Given the current economic scenario, developing border environmental infrastructure may not be seen as a strategic need.

Another source of funds for border environmental infrastructure is the North American Development Bank (NADB), which is a binational financial institution that provides low-cost financing alternatives for border projects that fall within the scope of its mandate (see Table 1) and which are previously certified by the Border Environment Cooperation Commission (BECC). Currently, the NADB has four lending mechanisms to support the construction of environmental infrastructure: a traditional loan program that offers funds at market rates or low-interest rates; a Border

Environmental Infrastructure Fund (BEIF) that allocates grants from the Environmental Protection Agency (EPA) for municipal drinking water and wastewater projects; a Solid Waste Environmental Program (SWEP); and a Water Conservation Investment Fund (WCIF).[7]

The NADB is an important financial intermediary in the border region. A recent report indicates that as of September 2009, BECC had certified 161 environmental infrastructure projects with an estimated cost of $3.46 billion. The same document mentions that NADB has contracted more than $1.03 billion in loans to support 130 of these projects, which represents 93% of all approved funding (NADB-BECC 2009). These numbers are good indicators of the importance of NADB in terms of project financing. Unfortunately, these indicators do not permit a proper assessment of two issues that are crucial to understanding some of the challenges of this funding mechanism: the cost of financing loans with NADB and the capacity of the borrower to repay them.

These issues were among the concerns of various federal agencies in the U.S. more than a decade ago. In 2000, the U.S. General Accounting Office (GAO) released a draft version of a report that discussed the status of environmental infrastructure in the U.S.-Mexican border region (GAO 2000). On that occasion, the EPA, the Department of State, and the Department of the Treasury voiced their concerns about the cost of financing associated with NADB loans.[8] As the Department of State highlighted at the time, "[t]here [was] a wide perception that the low level of lending by the NADBank result[ed] largely from its inability to offer lower than market rate financing mechanisms that would make loans more affordable or attractive to poorer border communities." Interestingly, for the Department of the Treasury the problem was not the interest rates charged by NADB but the limited financial capacity of many border communities and their ability to pay back any bank loans. Do we have the same situation today?

To find out, one must first ask how expensive a NADB loan is when compared to other funding alternatives. When GAO released its report in 2000, the Department of the Treasury stated that while NADB loans were competitive in Mexico, the Bank was not able to compete with the heavily subsidized programs that existed in the United States (e.g., tax-exempt municipal financing or state revolving funds). This situation has not changed significantly. According to NADB officials, the Bank charges Mexican clients interest rates ranging between 8.6% and 10.5%, which are usually lower than those charged by commercial banks. And while numbers were not available for the United States, the Bank's officials considered that NADB rates were still high compared to lending programs sponsored by federal and state governments (especially for water and wastewater projects).[9] This is an important challenge that policymakers in the United States still need to address. As a recent assessment of infrastructure needs for the state of New Mexico recognizes, "[a]lthough the general perception may be that environmental infrastructure is more commonly available in US communities, there continue to be populations in the US without adequate water, wastewater, solid waste services and paved roads" (BECC 2009). Herein lies the importance of exploring measures to try to enhance the competitiveness of the NADB in terms of interest rates. These efforts, nevertheless, cannot (and should not) rely on the use of subsidies or grant programs to lower the cost of borrowing. Even if the effectiveness of these policy tools could be demonstrated, current and expected budget constraints will make it difficult to guarantee grants of subsidies that are large enough to reduce the interest rate for NADB loans.

The repayment capacity of borrowers, which is the second problem mentioned in the response to the GAO report from the Department of the Treasury, remains a challenge for the border region. Since poverty is common in many border communities, finding ways to reduce interest rates is not enough. It must be made clear that a model of financial intermediation will not be successful if its implementation is not accompanied by policy measures to foster regional development.

Where to from Here? Alternative Funding Mechanisms

Banking and Investment for the Environmentally Conscious

One of the objectives of this paper is to invite readers to explore policy alternatives that could help bridge the existing gap in environmental infrastructure. While there will be cases in which the provision of a good will not occur without public financing, there will be situations where private participation is feasible. There is increasing interest from private investors regarding environmentally related businesses. The size of this market has been growing steadily and, to some extent, reflects the interest of many companies and corporate investors to allocate investment funds in areas labeled as "green technologies" or "socially responsible investments."

Labatt and White (2002) discuss some of the products that private financial institutions are creating to meet the demands of environmentally conscious investors. One possibility that they mention involves financial products that banking institutions offer to clients that meet environmental performance standards and seek easier access to capital markets. Some of these financial products could even be used to complement existing government programs to finance projects with limited profit potential. According to these authors, many banks have been creating products such as environmental loans and leases to promote the creation of environmental markets (e.g., water purification equipment and sustainable energy products), or have been active participants in the funding of projects that are capital intensive and offer little or no profit. There is a wide array of products that banking institutions around the world are creating to access an increasingly attractive market niche (see Table 2).

A second possibility is to explore the potential effectiveness of financial products that fall within a category of investments known as "Socially Responsible Investing" (SRI). This is a business strategy that privileges the inclusion of social and environmental standards to the criteria that are used to decide investment allocations. According to a report by the Social Investment Forum (2007), this is a $2.71 trillion market that comprises approximately 11% of total assets managed only in the U.S. and that is growing faster than the broader universe of assets. The same report indicates that this growth is partly explained by an increasing demand for products offering good rates of return, that promote environmentally friendly projects, or that incorporate social development indicators in the criteria to assess companies. The demand is particularly driven by the opportunities offered by areas such as green technology, alternative and renewable energy, green building and property development, and other environmentally driven businesses.

Table 2. Environmental Products Offered by Banking Institutions

Product	Main Features	Offering Institution (List is not exhaustive)
Preferential banking packages	Products to promote environmental care offered to holders of current accounts. The balance in customers' current account used for loans and investments in sustainable development projects.	Cooperative Bank (United Kingdom)
Green mortgages	Buyers of sustainably built homes negotiate loans with lower interest rates. Homes must comply with stringent standards for energy use, water conservation, use of materials, and internal environment.	ING Bank Dutch Government Green Project Schemes Cooperative Banks
Green certificates	Tax incentives to investments in green projects that meet the criteria for "green certification"; private individuals investing in the system are also eligible for tax exemptions.	Dutch Government (Green Fund System)
Financing of environmentally favorable projects	Promote investments in areas like environmental technology, energy efficiency, environmental management, soil remediation, or recycling infrastructure.	

Source: Labatt and White 2002.

The Dow Jones Sustainability Indexes (DJSI) are a good example of the opportunities that private investment can bring to the border region. The DJSI tracks the financial performance of the leading sustainability-driven companies worldwide. The size of this market, if measured by the value of the stock that asset managers hold, is over $8 billion. What makes these stocks different from others is that investors (or fund managers) will pay attention to measures of sustainability that are quantifiable and show that a project (or company) meets a series of predetermined environmental standards.[10]

The criteria to judge if a company meets environmental and social responsibility goals are still under debate. While some organizations consider many of the elements used in the screening and assessment of companies to be ideological,[11] some of the projects identified in the most recent needs assessments could be compatible with SRI guidelines (one example would clearly be green energy). Exploring this possibility implies that the project sponsor is willing to disclose information about factors that would be required to establish eligibility. This is precisely one of the challenges that asset owners and managers face in emerging markets, where disclosure on environmental, social, and governance factors is not common (EMDP 2009).

SRI may be useful for the development of environmental infrastructure in the border region. An interesting issue to be researched would be whether some of the indicators that fund managers analyze can be incorporated into BECC's certification process. This is not an unreasonable possibility, especially if the project to be financed has reasonable margins of profitability and if project sponsors conclude that the SRI business model can effectively reduce the cost of borrowing. If this is a funding alternative that governments want to consider, it will be necessary to make decisions about the sectors where private investment will be permitted, whether disclosure requirements will be honored, and if the necessary changes to the regulatory framework will be enacted.

Thinking Outside the Box: How About a Binational Debt-Financing Model?

The previous section serves to illustrate that the private sector can contribute to the development of certain environmental projects through financial packages that banks create and through investment funds that pay close attention to factors related to corporate sustainability, social responsibility, and environmental preservation. This could be an important method to develop critical infrastructure in the border region. The question, however, is whether those investment flows can be channeled to the type of projects that BECC identified in its latest assessment. But even if this is the case, it should be noted that these are decisions that the private sector needs to make (i.e., fund managers, banks, companies, etc.). Governments can promote the establishment of companies that are interested in corporate sustainability. Yet, the decision to meet with sustainability and social responsibility standards pertains to the companies themselves.

There are other policy alternatives that border governments could use to attract private investment to the region. One of these alternatives involves the development of subnational capital markets. At first glance, it may appear that a proposal to explore these markets would be more appropriate for Mexico because, as Erickson and Eaton (2002) point out, state and local governments in the United States have been accessing these markets for a long time. But if one takes into account that the benefits, costs, and risks associated with many border projects are of a binational nature, then it is important to start thinking about policy innovations from a binational perspective as well. With this premise in mind, the proposal is to consider the possibility of granting a subnational government in Mexico and a subnational government in the United States access to the debt market by issuing debt instruments jointly.

The existing regulatory framework permits the existence of a separate decision-making model in terms of project financing. This situation is understandable if one considers the fact that Mexico and the United States are sovereign countries with their own regulations and infrastructure development programs. One must wonder, however, if this is the best way to proceed. An illustrative example of the perils that a funding method like this entails is the case of international border crossings. Traditionally, paying for the construction of a new port of entry has been a federal government responsibility, but as already explained, tighter budget constraints and shifting policy priorities have induced governments to explore alternative funding methods. In Mexico, the tendency has been to rely more on public-private associations while in the U.S., a recent experiment has been to grant local governments the authority to issue bonds and impose user charges to secure debt repayment.[12] But what would happen if, for any reason, one of the parties involved is not able to secure its share of the funding in a timely manner? Why not extend coordination efforts to issues related to infrastructure finance?

A binational debt-financing model would allow governments on both sides of the border to enter capital markets in better conditions. A funding model like the one proposed here is based on the idea that pooled financing methods can contribute to reduce issuance costs and reduce interest rates for the borrowers. This is a plausible idea especially since Mexico and the United States already have a positive experience with joint financing operations—the North American Development Bank. The problem, as already explained, is that NADB works with a restrictive mandate that limits the projects to be financed. A binational debt-financing model would enable governments in the border region to mobilize private savings and pay for projects that NADB cannot finance.

At this point, it is important to mention that there is a difference between obtaining the funds for a project from commercial or development banks and from the bond market. Bank lending and bonds are models of financial intermediation with different characteristics (Peterson 2002).[13] In the former case, we are considering a financial intermediary that monitors issues affecting loan repayment on behalf of the investor. In the latter case, the investor who considers the purchase of a bond must perform some of these functions. Both models have advantages and limitations that policymakers in Mexico and the United States would need to consider. One of them is the ability of a policy to allow subnational governments access to the capital market directly (as issuers). In this case, investors would need to monitor the financial condition of the issuing governments directly and would need to assume the risks associated with the project.[14]

Both models of financial intermediation—banking and bond markets—have advantages and limitations that policymakers need to consider carefully. The NADB gives a clear idea of the possibilities that a binational and well-funded institution can offer to the border region. However, if there is interest in developing the latter option, both countries will need to engage in a process of institutional harmonization. The countries of the Association of Southeast Asian Nations (ASEAN) can serve as a good reference point to understand the steps that Mexico and the United States would need to take, as the ASEAN countries have been working on the creation of a regional bond market since the 1990s (Asian Development Bank 2008). Ismail Dalla (2003) summarizes some of the specific steps that member countries are taking to move forward with this process. As he points out, a harmonization process to foster regional bond markets must encompass issues such as tax treatment, credit rating requirements, trading platforms and conventions, clearing and settlement procedures, accounting and auditing standards, and foreign exchange regulations. If both countries truly want to explore innovative means to finance strategic border infrastructure, then leaders should engage in a constructive dialogue to evaluate the feasibility of a binational bond market mechanism like the one proposed in this paper. If a basic agreement in this regard can be attained, it would be our task, as scholars, policymakers, and residents of the border, to achieve the objectives that would bring this project to fruition.

ENDNOTES

[1] The U.S.-Mexico Border Program is administered by the U.S. Environmental Protection Agency (EPA) and serves to fund critical infrastructure along the border region. The program focuses on cleaning the air, providing safe drinking water, reducing the risk of exposure to hazardous waste, and ensuring emergency preparedness. See http://www.epa.gov/usmexicoborder/ (Accessed 1 April 2010).

[2] An important clarification needs to be made at this point. While the authors use the term user fees in their document, there is a difference between user fees and user charges. The former refers to revenues derived from the sale of a license to engage in an activity that would otherwise be forbidden or restricted. The latter refers to the price that a government can impose for the voluntary purchase of a publicly provided good or service (Mikesell 2007).

[3] There are many types of bond instruments. Interested readers may find additional information in Leonard (2004).

[4] These estimations are for the six Mexican states (Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas) and it only includes the 100-km range that extends south from the international line. The investment needs are for drinking water, sewer systems, and solid waste.

[5] A good or service is of a public nature when it becomes difficult to charge consumers a price for its use or when the use of such good or service does not preclude others from using it. This, however, is a broad definition that may vary among cases or across countries. One example would be water, which in Mexico is considered a national resource and a right that should be available to all consumers. In the United States, in contrast, water is perceived as a service for which consumers need to pay.
[6] There are other sources of funding for border environmental infrastructure projects. As EPA points out, there are strategic investments where state and local governments or bilateral or multilateral organizations such as the World Bank, Inter-American Development Bank, or North American Development Bank participate. While their participation in the financing of border projects can be significant, this paper will not analyze their contributions in detail.
[7] Details about these programs are available on the NADB's website: http://www.nadb.org/programs/brdrenv.html (Accessed 1 April 2010).
[8] The response letters are included in the appendix of the GAO report.
[9] The author thanks Juan Antonio Flores (Associate Director of Public Affairs at NADB) and his staff for providing this information.
[10] The elements that they take into account when assessing investments consider different dimensions; these are available at: http://www.sustainability-indexes.com/07_htmle/assessment/criteria.html (Accessed 1 April 2010).
[11] See http://www.ncpa.org/pub/ba657 (Accessed 1 April 2010).
[12] This method will be put into practice in the construction of the U.S. portion of the Otay East International Crossing between California (United States) and Baja California (Mexico). See SANDAG, "State Route 11 and Otay East Port of Entry" (Accessed 1 April 2010): http://www.sandag.org/index.asp?projectid=56&fuseaction=projects.detail.
[13] There is an extensive literature dealing with issues of financial intermediation and credit market development. The literature is not discussed in this paper for reasons of space. Interested readers could review: Douglas (1991); Freire and Peterson (2004).

[14] The term investor is used broadly in this sentence. While it may certainly refer to the owner of the funds to be lent (e.g., savings), there are other actors in the bond market that may serve as a link between the issuer and the final investor. Bonds issued by government agencies are usually sold through entities called underwriters, which are groups of investment or commercial banks that purchase the bonds and resell them to investors. A more detailed explanation can be found in Leonard (2004).

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XVI

Summary of Border Institute X: Toward a Sustainable 2030

Paul Ganster and Erik Lee

Overview

Border Institute X, held March 8–10, 2010, in Rio Rico, Arizona, assembled community leaders, academic researchers, and members of nonprofit organizations as well as local, state, and federal government officials from both sides of the U.S.-Mexican border to evaluate changes in border environmental quality over the past decade and to suggest policies and actions for a road map to a sustainable region in 2030. Papers presented at the various panels provided current information on the border environment, identified challenges, and suggested policies to help achieve a sustainable border region. These presentations are included as chapters in the present volume.

Summary of Keynote Presentations

In addition to the prepared papers presented at the various Border Institute X panels, keynote speakers stimulated substantive analysis and discussion through their remarks. The keynote speakers' input complemented the themes discussed by the panels and highlighted relevant information about institutions and mechanisms that are critical for managing the border's environment and guiding the region on a more sustainable path. These presentations were about the San Diego Association of Governments (SANDAG), the Border

Environment Cooperation Commission (BECC), Border 2012, the Good Neighbor Environmental Board (GNEB), and the Border Liaison Mechanism (BLM).

Héctor Vanegas of the San Diego Association of Governments (SANDAG) provided conference participants with an overview of the agency and updates on SANDAG projects and studies. SANDAG serves as a regional model for binational collaboration. Its board of directors includes representatives from 18 cities and the County of San Diego, as well as from the Consulate General of Mexico in San Diego, a representative from Imperial County, and a tribal leader representing the 18 tribes in San Diego County. Within SANDAG, the Committee on Binational and Regional Opportunities (COBRO) works very closely with Mexican border municipalities and Tijuana's Municipal Planning Institute (Instituto Municipal de Planeación–IMPlan). SANDAG is a member of the governing board of IMPlan. SANDAG and IMPlan have worked diligently to develop a good working relationship, creating the opportunity to incorporate perspectives from both sides of the border in their ongoing planning activities.

Two of SANDAG's largest projects—the Regional Comprehensive Plan and the Regional Transportation Plan—have a binational component in order to incorporate input from Mexico. The goal is to "create a regional community where San Diego, our neighboring counties, tribal governments, and northern Baja California mutually benefit from our varied resources and international location."[1] SANDAG is a successful system of partnerships because of the dedication and respect among authorities and stakeholders. A key part of building binational trust is based on acknowledging cultural differences and proposing projects and solutions that reflect this understanding. Key planning areas for the binational region include transportation, water and energy supply, environment, and economic development.

SANDAG's Otay Mesa-Mesa de Otay Binational Corridor Strategic Plan was developed by COBRO and focuses on transportation, housing, economic development, and environmental conservation within the corridor. The plan was introduced in 2007 and the agency is moving forward with its implementation. The most recent progress report, released in March 2010, indicated that the environmental reviews for construction of SR11 and the Otay Mesa East POE were under way, with completion expected in 2011, and that SANDAG is leveraging funds from multiple sources in order to ensure sufficient funding for completion. Monies made available through loans will be paid back from toll revenues. The new toll road and port of entry will help reduce the idling time of vehicles and trucks northbound across the California-Baja California border by handling traffic more effectively. In addition, SANDAG is working toward optimizing efficiency at the existing Otay Mesa POE, including adding more lanes and modernizing the facilities and the interdiction mechanisms. As part of the plan to increase border-crossing efficiency, bus transit routes in San Diego County's South Bay area in the U.S. and in Tijuana in Mexico are being expanded to better serve the frequent border-crossing population. Parallel to the infrastructure plans are environmental actions designed to address conservation of sensitive habitat and urban river corridors, such as the Alamar River in Tijuana and the Otay River watershed in San Diego. The action plan includes identifying critical habitats, purchasing conservation easements, and then determining the value of environmental services provided by the intact ecosystems so that beneficiaries are charged and the city can use the fees to conserve the land (and the services). According to Vanegas, one of the greatest challenges to implementing the plan is getting approval and action to match on both sides of the border, especially due to the frequent administrative changes that take place on the Mexican side. Further, POE legislation in the U.S. does not allow for public-private partnerships, only public-public, and this makes garnering sufficient financial support for the project on both sides of the border more difficult.

In 2005, SANDAG released the results of its first economic impact study for waiting times to cross at California-Baja California ports of entry. The study revealed that the delays cost the region exceedingly in revenue, potential working hours, output, and job stability. The study was updated in 2007 and found that the region missed the opportunity to take advantage of $7.2 billion of economic activity and to create 62,000 jobs.[2] Another update of this study is forthcoming.

John Dinkelman, Principal Officer to the U.S. Consulate in Nogales, Sonora, discussed the success of utilizing the Border Liaison Mechanism (BLM) in Ambos Nogales. The BLM is a joint governmental instrument that is intended to allow authorities to better coordinate bilateral activities and operations. The BLM is set up via a Memorandum of Understanding between the U.S. Department of State and Mexico's Ministry of Foreign Affairs (Secretaría de Relaciones Exteriores–SRE) and convenes officials from both sides of the border to discuss issues of mutual interest. It is often used to address concerns and needs that arise at the local level but which fall within federal authority. Dinkelman cited the success of using the BLM in the Arizona-Sonora and Laredo-Nuevo Laredo border regions to develop binational border violence protocols for local authorities. These protocols allow for immediate communication between first responders and define procedures for handling emergency situations in a binational manner. These protocols are frequently updated to reflect the changing reality of the border region and practice drills keep law enforcement actions harmonized.[3] Part of the success in the Arizona region is due to the foundation of cooperation established by the Arizona-Mexico Commission. This decades-old forum for bilateral communication made for a straightforward transition to the BLM structure for security-related activities.

In addition, the BLM gives local-level authorities the opportunity to express their views to their counterparts on the other side of the border. However, Dinkelman cautioned that a request in itself to discuss an issue does not mean that Mexico will find the issue to be of equal importance, especially given the resources and staff time involved in coordinating BLM meetings. Therefore, a request does not guarantee a meeting, but rather serves to begin discussing an issue.

The keynote "BECC: Analysis of Border Environmental Infrastructure Priorities, Now and to 2030," was given by Maria Elena Giner, General Manager of BECC. Despite the numerous environmental challenges afflicting the border region, the BECC has been remarkably successful in mitigating possible environmental impacts of the population explosion in the U.S.-Mexican border region over the last 15 years. Since the BECC has been in existence, 167 border infrastructure projects have been certified for funding. The idea behind the BECC-NADB is to strengthen and continue binational reciprocity through construction and management of environmental and human health infrastructure. The NADB itself has financed 132 of these projects, for a total of $1.08 billion. Moreover, the NADB is very efficient at leveraging project resources; for every one dollar invested, it has leveraged two dollars in matching funds, raising total investment to $3.65 billion.

Recently, economic competition has pushed construction quotes down dramatically (20% under budget in some areas) allowing the BECC-NADB to finance more of these projects for less. These projects benefit the 29.7 million border state residents by improving their quality of life and access to basic services.

Water management infrastructure—whether in the form of access to potable water, sewage and solid waste control, or wastewater treatment—has long been the focus for the BECC. According to Giner, progress has been impressive with all three types of water infrastructure in the border region since 1995. As of 2009, 96% of the border region residents in Mexico had access to potable water, up from about 40% in 1995. Sewage infrastructure was hovering around 35–50% for Mexican border states in 1995 and is now averaging 85–90%. But it is in the area of wastewater treatment that Mexican border states have seen the most improvement. In 1995, wastewater treatment was minimal, ranging from zero coverage in some areas to a maximum of about 50% in Baja California. Beginning in 2009, wastewater treatment ranged at about 7 to 90% coverage for the border region. The great expansion of coverage is the result of a collaboration of the USEPA, the National Water Commission (Comisión Nacional del Agua–CONAGUA), and other agencies through the U.S.-Mexico Border Program, according to Giner.

Recently, the BECC has made significant efforts to expand the scope of its infrastructure initiatives to include energy efficiency and renewable energy source development. Its objective is two-pronged: mitigate the effects of climate change and reduce the costs associated with energy demand. This is particularly important for water utility operations. As of 2010, Mexican water utilities spent approximately 70 to 80% of revenue on energy costs; for the U.S. that figure was 40 to 60%. Efficiency and renewable development have the potential to reduce this cost dramatically, allowing water utilities to service more people. The BECC also recently completed greenhouse gas emissions inventories and diagnostics for 1990–2020 for the six Mexican border states and developed the Borderwide Strategic Plan. The plan is an overall needs assessment of the region and is intended to direct investment toward improving the effectiveness of infrastructure where it will have the greatest benefit.

Although the BECC and NADB are very creative with developing joint funding for infrastructure projects, they also rely on Border Environment Infrastructure Fund (BEIF) financing that is from Congress and channeled through USEPA, which has diminished in recent years. Since 2010, the BECC has identified $800 million worth of unfunded needs, while the fiscal year 2011 Congressional appropriation for the BEIF was only $10 million. Generally, all levels of government on both sides of the border are struggling to fund investment or operation and maintenance needs. Without sufficient investment from all parties on both sides of the border, the population will overwhelm the service infrastructure and make it increasingly challenging for the BECC-NADB to secure funding for new services, let alone for rehabilitation of older infrastructure. Giner concluded that, "We need continued support for frequent information exchanges and centralized access—I mean, that is what this conference is all about."

The "Border Governors Conference Strategic Plan," was presented by Carlos de la Parra from El Colegio de la Frontera Norte. Traditionally, the border governors have utilized the Border Governors Conference to develop and sign a series of declarations to be carried out in each of the states over the coming year. However, at the 2008 XXVI Border Governors Conference in Hollywood, California, the governors decided that they wanted to develop a more long-term vision for the border region. They began the process of developing a Master Plan for Competitive and Sustainable Development in the U.S.-Mexican Border Region to be implemented by 2030. The preliminary version of the plan was crafted over the next year and presented to the governors at the XXVII Conference in Monterrey, Nuevo León, in 2009. The governors adopted the nonbinding plan in Monterrey, and the plan continues to be developed for the BGC.

The plan has four areas of focus: global competitiveness, environmental sustainability, border and citizen security, and quality of life. Although socioeconomic, environmental, and security issues in the border region present a number of different challenges, there are also significant opportunities for their improvement and "opportunities provided by a crisis should be capitalized on to change the structural issues, which, in turn, define the medium- and long-term goals," according to de la Parra.

The border governors are committed to leveraging the potential of the binational border region as a market force to compete with other emerging regional markets, emphasizing the need for improved transborder mobility and investment in border infrastructure, with sustainability as a metric for planning. According to de la Parra, sustainability is a significant theme of the plan and, in order to achieve sustainability in the border region and avoid patchwork protection, policies and environmental regulations must be as consistent as possible on both sides of the border and through all levels of government.

Securing the border region is dependent upon trust. Both nations need to be able to trust each other and share critical information that increases regional security. Binational coordination among security personnel, including training and resource availability, will allow for more efficient response to security emergencies and natural disasters. Quality of life will be improved if efforts in the other three categories yield positive results. Economic opportunity, environmental health, and resource availability, along with improved citizen security, will likely lead residents of the border region to subjectively believe that their quality of life has improved, which will lead to a stronger, more robust border region.

Sally Spener of the International Boundary and Water Commission (IBWC) discussed the agency's recent work. The IBWC is charged with applying boundary and water treaties between the U.S. and Mexico. The U.S. section of the IBWC and the Mexican section known as the Comisión Internacional de Límites y Aguas (CILA), together manage binational water infrastructure projects including levies, dams, wastewater treatment plants, and hydroelectric plants. They also assure the correct demarcation of the border between the U.S. and Mexico. President Obama appointed Edward Drusina as the new commissioner of the IBWC in January 2010. As commissioner, Drusina is committed to enhancing public participation in determining binational water infrastructure priorities. IBWC is focused on three primary issue areas right now: dam safety, sanitation infrastructure, and flood control.

Dam safety is a major concern for the IBWC. After completion of a standard five-year safety inspection in 2007, a binational panel of engineers found that Amistad Dam at Del Rio, Texas, was rated urgent and potentially unsafe due to natural sinkholes. IBWC/CILA attempted to repair the dam using grout, but seepage is still occurring. Other dams, such as the Falcon Dam (second largest on the Rio Grande), have safety issues, but none as significant as that of Amistad. The goal of IBWC/CILA is to develop recommendations for appropriate repairs to be funded and implemented by both countries. Much of the dam infrastructure along the border was built during a time when environmental concerns were not as significant to engineers, policymakers, and stakeholders as they are today. Engineers and officials are reevaluating traditional methods and techniques for repairs in light of environmental concerns.

Sanitation is another major issue within the border region, especially in areas where transboundary surface waters carry sewage across the boundary line. However, construction of three international wastewater treatment plants has helped to control transborder sewage and water pollution. The plant in Nuevo Laredo, Tamaulipas, currently treats 22 mgd from the City of Nuevo Laredo to the secondary level. Prior to construction of the Nuevo Laredo plant, the untreated waste from the City of Nuevo Laredo flowed directly into the Rio Grande. Construction was funded by both IBWC and CILA and the plant is operated by Mexico.

The South Bay International Wastewater Treatment Plant in the San Diego region is owned by the U.S. section of the Commission and treats 25 mgd of sewage flowing north from Tijuana. Prior to construction, the untreated sewage entered the U.S. through the Tijuana River. The plant was completed in 1997 to treat the sewage to advanced primary, but is currently in the process of being upgraded to treat sewage to the secondary level before it is released through the outfall pipe into the Pacific Ocean. Secondary treatment will bring the plant into compliance with the Clean Water Act. On January 5, 2011, IBWC announced that the plant had begun treating sewage to secondary standards.

The Nogales Wastewater Treatment Plant treats sewage from Nogales, Sonora, and Nogales, Arizona, with about 80% of the sewage coming from Mexico. The plant treats approximately 15.5 mgd. A technology upgrade of the facility was completed in August 2009 to improve the quality of water discharged into the Santa Cruz River. The upgrade was funded primarily by the USEPA through the Border Environment Infrastructure Fund. The plant is operated and maintained by the U.S. side of the Commission and the City of Nogales, Arizona.[4]

Flood control is another major issue along the Rio Grande; designing levy infrastructure and flood plain maintenance require international cooperation. Both nations must agree upon the design of the levy systems and the capacity in cubic feet/second. This will depend in large part on the surrounding land use types, as well as local topography and geology. Each side is responsible for constructing and maintaining levies on its own side. Many of the levy systems currently in place are out of date (three to 70 years old) and need to be recalibrated. Primary areas of concern for levies are at El Paso-Ciudad Juárez, Presidio-Ojinaga, and the Lower Rio Grande. IBWC received $220 million in Recovery Act funds to raise and rehabilitate Rio Grande levies to meet the Federal Emergency Management Agency (FEMA) criteria. A significant issue that must be addressed with these funds is the need to better protect rural communities in the event of a catastrophic flood. Rural areas do not have the high level of protection in levy systems that larger cities have. Recovery Act monies will also fund environmental mitigation activities intended to reduce the impacts of flooding. In the 1990s, IBWC/CILA modified mowing practices in the floodplain to establish wildlife corridors and allow growth of native plant species, particularly native cottonwood. IBWC recently released a Record of Decision, after much public input, to implement the Rio Grande Canalization project to improve flood control, water delivery, and operation and maintenance in a manner that would enhance or restore river ecosystems. Additional actions include removal of invasive species and phasing out grazing leases in order to reduce bacteria and erosion.

Another geographic area of particular concern is the Santa Cruz River with the transboundary Nogales Wash. In 2007–2008, severe storms damaged the wash drainage tunnel and a number of panels of the wash channel, causing flooding in both Nogales. This was exceptionally dangerous because the international outfall interceptor (the pipe that conveys sewage from the border to the treatment plant) was exposed when the panels of the wash collapsed. Had the pipe been broken, the area and waterway would have been contaminated and this could have caused a public health catastrophe. IBWC is working to identify solutions and is conducting studies to prevent this.

The keynote presentation "Border 2012," by Lisa Almovador of the USEPA Office of International Affairs, provided an update for the Border 2012 Program and notified the group that EPA is seeking recommendations and suggestions for the next version of the program. Border 2012 built on and improved what was learned from the earlier Border XXI program. Partners in the program include USEPA and SEMARNAT, with input from 26 tribes on the U.S. side of the border, the BECC and NADB, and the Good Neighbor Environmental Board (GNEB). The focus of Border 2012 is to utilize the bottom-up approach for improving environmental quality in the border region, with more interaction and collaboration among stakeholders.

Almovador reported that as of March 2010, 75% of the objectives of Border 2012 Program had been completed. These related to reducing air pollution, improving access to clean water and wastewater treatment, reducing land contamination, improving environmental health, improving coordination of contingency planning and emergency response, and enhancing cooperation and enforcement of environmental management systems in the U.S.-Mexican border region. Almovador expects that all goals will be met before the end of the Program in 2012.

The status of the Border 2012 Program and suggestions for its next phase have been presented to EPA Administrator Lisa Jackson, and the program has her approval to move forward with the next phase. As part of the National Coordinators Meeting in October 2009, Border 2012 coordinators asked participants to suggest new goals/objectives, organizational structure alternatives, methods of communication, and leveraging resources for the new program. Specific feedback from the group included a number of recommendations, questions, and comments. These included:

- Bring the Department of the Interior back as a partner in Border 2012. What other federal agencies should be brought on as partners?
- Increase focus on environmental justice issues in the border region
- Include climate change adaptation and mitigation strategies in new goals and objectives

- Include proper disposal of e-waste among objectives
- Carry over the goal of better understanding how to improve communication where there is a disconnect between levels of government and between government and stakeholders
- Find alternative resources to support Border 2012 initiatives, given that EPA funding has been diminished; CEC or the Borders Governors Conference are both possible sources

Paul Ganster discussed the Good Neighbor Environmental Board's "13th Report on Border Environmental Priorities." The GNEB 13th Report to the President and Congress identifies critical environmental issues in the border region. The report includes descriptions of the issues, challenges to resolving the issues, and policy options that could lead to solutions for the issues. Topics covered in the report include climate impact, adaptation, and mitigation; air quality; energy; water quality and quantity; solid and hazardous waste management; emergency preparedness, including chemical and terrorist incidents and natural disasters; habitat and biodiversity conservation; and institutional mechanisms to improve the ability of federal government to facilitate resolution of environmental problems along the border.

As the advisory board to the President and Congress on border environmental issues, GNEB occasionally writes advice letters on specific issues that warrant special attention. For example, in December 2009, the Board sent a letter to President Obama informing him of the environmental effects of construction and maintenance of the U.S.-Mexican border fence, and that a "one size fits all" approach to fence construction is not the best way to ensure a secure border. The letter detailed the types of environmental impacts already occurring, pointed out where the fence has had a positive impact on the environment, and made suggestions for varied technologies to be deployed along the border and, in some cases, to replace the traditional fence.

There is a general consensus among Board members that Mexico should be more involved in GNEB activities. GNEB is an advisory board made up of U.S. citizens reporting to U.S. governmental officials, but regular input from Mexico would be useful in defining regional issues and making recommendations to be included in the reports.

In addition to the keynote addresses, a final component of the Border Institute X was the last day of discussions and conclusions. Paul Rasmussen, who was the USEPA Project Manager for SCERP and a participant at Border Institute I, observed that, "The challenge for these meetings is to think of this decision making in sustainable terms." Ganster, Chair of SCERP and also present at Border Institute I, noted that, "There are a lot of ways to resolve border environmental problems that don't require huge financial investment, but simply better coordination, linking efforts of different federal agencies, and eliminating legal and technical barriers to facilitate the work of states and communities; a lot can be done without a lot more money." Ganster also pointed out that this reframing of needs and options will be critical to meeting existing and future challenges, given the limited prospects for funding of border projects in the near future.

Summary and Conclusions

On the final day of Border Institute X, participants convened in small groups dedicated to selected topics related to the border environment. The four breakout session groups formed were:

- Watergy (water quality and supply in the border region and energy associated with conveyance and treatment)
- Ecosystem services, population, and security (the intersection between the three)
- Climate change, air quality, and energy (as interdependent variables)
- Border governance and financing border infrastructure

It is important to note that dividing the issue areas was not without challenges. Ultimately, each of the issues cannot be analyzed nor planned for without looking at the relationships among all factors. One participant noted, "How can we consider planning for freshwater availability in the border region without examining it in the context of ecosystem services?" This illustrated a key obstacle referred to throughout the conference. The theme of the conference—how to achieve a sustainable border region in 2030—requires interdisciplinary planning among agencies, communities, and organizations. Consideration and recommendations regarding the future status of a single topic is not likely to be helpful if considered as an isolated phenomenon, or the silo approach.

After discussion, the rapporteur for each of the four breakout session groups presented to the plenary group the perspectives and recommendations shared during the discussions. These include the following:

Watergy

Currently, many areas of the border region suffer from critical water shortages. These shortages can be a significant source of regional and binational conflict. For example, the Colorado River feeds the water demands of seven U.S. states and the state of Baja California and part of Sonora in Mexico. Arid and relatively warmer climate conditions in recent years have reduced the flow of the mighty Colorado. Yet, each of these states continues to extract surface water to the extent authorized by the Colorado River Compact of 1922 and the 1944 water treaty between the U.S. and Mexico. This high extraction rate, combined with pollution from urban growth and agricultural runoff, means that the water quality is degraded and the water quantity is below a sustainable level for extraction by the time it reaches the lower basin states in the U.S. and Mexico. This creates tension among the U.S. states and between the U.S. and Mexico.

In addition to these surface water issues, there is no jurisdictional mechanism at present to manage binational groundwater resources in a coordinated and efficient manner. The lining of the All-American Canal is a particularly contentious issue because seepage from the canal historically had charged an aquifer in Mexico that provided water for irrigated agriculture in the Mexicali Valley. The former seepage is now retained on the U.S. side to meet U.S. needs. In the absence of a legal tool for regulating the binational aquifers and of an adequate characterization of the shared aquifers, it is a take-it-first-before-it's-gone mentality. This situation is likely to lead to a "tragedy of the commons" scenario. This reality is allowed to play out for several reasons: (1) Water is not viewed as a natural resource, the source of which must be protected, but rather as a commodity; (2) regional water managers continue to plan for demand rather than supply; (3) the existing laws and water rights system come from a prior period and do not serve the region well anymore, but are very difficult to change; (4) the complexity of agencies responsible for water delivery and allocation in the U.S. create competition for every drop; and (5) frequent changes in administrations and policymakers mean that institutional memory is lost. Working relationships developed and familiarization with the way the border operates in the context of water may be derailed when officials are replaced. The delay in rebuilding rapport stunts progress toward achieving an understanding and perhaps developing new binational policies.

The full cost of water is not borne by anyone in the region. Water use is heavily subsidized for agricultural production, which often leads to wasteful irrigation practices and even selection of crops that are very water inefficient. For example, water-scarce Southern California cultivates 95% of the water-intensive avocados grown in the U.S. Lobbyists for the agricultural sector use the façade of representing hard working farmers and American families that would not be able to afford the food produced in the U.S without the subsidies, when in reality they are lobbying to be inefficient; the subsidies have been shown to lead to wasteful farming practices. Drought conditions may force temporary rationing for farmers, but nothing is being done to prepare or change behavior for the long term. As soon as the rationing is lifted, the same wasteful irrigation methods will continue if the subsidies are still there.

General users receive water at an artificially low price. The cost is artificially low because the environmental impacts of low water tables, polluted water, diminishing fishery populations, and debilitated riparian ecosystems are not factored into the price charged to consumers. In other words, consumers do not pay the true, long-term cost of water they use. Consumers of today defer some of the costs for water production and supply to be borne by future generations.

In addition to the environmental impacts on the waterways, the energy used to pump, transfer, convey, and treat the water produces air pollution in the region (causing respiratory health costs) because most border-state energy sources are fossil fuel-based and the provision of water to citizens requires an enormous amount of energy. For example, water is the single largest consumer of energy in the state of California, driving approximately 20% of total demand. Although there are some areas where hydroelectric power is generated by the gravitational force of water flowing downhill, this is only a small percentage of the total amount of energy used by the various water projects. External costs such as the health effects of air pollution or destruction of riparian ecosystems and the environmental services they provide are assumed by society in general and are not recognized by consumers as factors that should affect their cost of water. It is very difficult to get consumers to adapt their pattern of water use in the absence of crisis-level conditions. The conflict then is water rights for human uses versus water for nature.

In 2030, with business as usual, demand for water will outstrip supply in the border region. Regional population growth rates generate demands for resources beyond the capacity of the region to provide these—particularly water—and quality of life will suffer as a result. Water quality will be much worse than it is today. Riparian ecosystems will suffer and, in some places, certain species may disappear altogether. The Conejos Médanos-Bolsón de la Mesilla and the Bolsón del Hueco-Valle de Juárez in the New Mexico-Texas-Chihuahua region will be depleted or degraded by overpumping as both countries continue to extract from them without binational management and agreements for use of this critical resource. Diminished surface water availability will force water managers to pull from all resources available in order to meet the ever-growing demand. As new, expensive technologies such as desalination (which tends to be the prevailing favorite among existing alternatives) are deployed to meet demand, the cost of water will increase dramatically.

The desalination industry is likely to boom throughout the region. However, if technology and energy efficiency do not improve, the amount of energy that will be required to separate the salt from the water will have a significant indirect impact on regional air quality due to increased demand for electricity production. There are also direct environmental impacts of desalination technologies that are of concern. At coastal desalination facilities, the pipes that deliver seawater to the plants often have inlets in the nearshore marine environment. This process kills significant quantities of marine life, often juvenile species of commercially important fish and invertebrates. Brine discharge from the desalination process also can have negative impacts on marine life. Coastal ecosystems at both ends of the border are fragile and desalination plants represent another potential threat. Inland desalination facilities face similar and additional challenges. Disposal of brine is a key concern, and the best options to date involve reinjecting the concentrated brine into deep formations that are isolated from aquifers with drinking water or with low salt concentrations that are suitable for treating for human use. These options require significant energy inputs. Some border regions also face difficulties in finding suitable supplies of water for desalination.

While treated wastewater is a good option most everywhere for desalination, groundwater deposits of saline waters for that purpose are sometimes limited and may be exhausted by 2030. Aquifers are complex and dynamic systems and react differently to heavy pumping and reinjecting brine or other liquids. Inadequate understanding of the structure of transborder aquifers may lead to long-term problems with these resources.

In order to achieve a sustainable border environment by 2030, it is time to identify, differentiate, and design for three categories of water users: agriculture, people, and nature. Although water demand for agriculture (around 80% in the border region) in many ways is part of the "people" category, it should be considered separately because the sector's use of water is not in the best interest of, or controllable by, the general population. There is a need to deliberately return a portion of available freshwater to nature, or to leave this portion untouched in the first place.

The Watergy breakout session developed specific recommendations to achieve this objective:

- Change public perception of the value of water
  - Lifestyle changes are necessary in order to accommodate realistic water budgets
  - Better "packaging" of what is known about the water crisis so that the public agrees and accepts the changes that are needed
  - Use the "virtual water" concept so that users are aware of the full amount (or volume) of water required to produce everything they consume, such as the water needed to produce a loaf of bread or a hamburger
- Increase the focus on efficiency and reuse of water resources—think reduce, reuse, recycle
  - Manage for supply and then for demand, not the other way around
  - Rather than subsidizing water for agriculture, subsidize the costs associated with converting to water efficient irrigation systems and climate-appropriate crops

  - More investment in research and building infrastructure for indirect potable reuse: use 10% of the energy required by desalination plants to produce an equivalent amount of potable water
- Better measurement of water resources
  - Properly characterize transboundary aquifers and determine sustainable extraction rates
  - Create a water budget for each watershed and for each user category within the watershed
  - Paradigm shift
  - Backtrack to end-user (the environment) and allocate water for each user from that point forward. Start with water for the environment and from there map water allocation forward
- Binational dialoguing—bringing parties to the table
  - Reframing and dialogue: How can we manage and care for our resources better, rather than managing through binational adjudication?
  - Use national projections for population growth and water as a basis for dialogue
  - Develop mechanisms for institutional memory at all levels of the binational process
  - Utilize the authority and resources created by the Transboundary Aquifer Assessment Act
- Link water to energy
  - Be more inclusive regarding all potential energy sources for powering water processes
  - Use carbon emissions as a metric to decide on energy sourcing
  - Consider water use associated with energy production, such as for cooling purposes; water is used to produce the energy that transports the water

Population, Ecosystem Services, and Security

Population and security depend on the vitality of ecosystem services. Currently, urban growth is causing significant stress on regional ecosystems. Balancing the needs of border residents, security initiatives, and regional ecosystems is challenging because the demands for ecosystem services are ever increasing. At the same time, the health of various regional ecosystems is diminishing. This affects the ability of the systems to continue to provide the desired services. Whether it is encroachment and habitat fragmentation through development, air pollution, agricultural and urban runoff, overexploitation of waterways, or unsustainable harvesting of flora and fauna, without mitigation strategies for the damage caused, the short-term gains will make the region ecologically unstable in the not too distant future. Due to the state of the border region's economy, it is difficult to convince people that resources are too cheap and that pollution must be better regulated and controlled. Unfortunately, many people continue to be under the impression that focusing on environmental concerns hinders economic growth. Moreover, the heightened emphasis on securing the border in the post 9/11 era has raised the concern that conducting appropriate environmental impact assessments on border security infrastructure projects might negatively affect U.S. national security.

With growing understanding of the dynamics of population, urbanization, economic growth, climate change, and other issues, it is clear to many scientists, community members, and some policymakers, that sustainability and quality of life outlooks for the border region of 2030 are not positive. Unfortunately, attention—both nationally and regionally—is focused on immediate concerns such as security issues, job creation, or meeting the near-term water demand. Little medium- and long-term planning for adaptation to the changing border circumstances is under way.

In 2030, with business as usual, fragmented and isolated landscapes will make it difficult for ecosystems to provide services depended upon by the human population. Vulnerability to the worst effects of natural disasters (such as floods and fires) will only increase. All the Colorado River Delta wetlands will have vanished. Food and fiber will have to be imported from other areas and natural resources (mainly soil and water) will be seriously degraded. Reductions in the Border Environment Infrastructure Fund and support for agencies that address border environmental issues are of great concern.

The widely held view in the U.S. that the priority for the border is to serve as a security and defense barrier against terrorism, drug trafficking, violence, and migration has deflected concern from critical environmental issues of the region. In particular, natural areas that support ecosystem services are under much pressure from development and construction of security infrastructure. In the U.S., exclusions, exemptions, and waivers have granted the Department of Homeland Security immunity from environmental review for border fence construction, raising concerns over the impact of security infrastructure on the border environment. A unidimensional emphasis on the border as a security zone will weaken international trade and the border economy, impact the environment, and affect quality of life. These, in turn, will compromise the security of the border.

In order to achieve a sustainable 2030, we need "sustainable security and secure sustainability." The breakout session group that covered population, ecosystem services, and security decided to frame their recommendations in economic development terms. Conceptualizing ecosystem services as financial and security benefits may be the best way to evolve and broaden the understanding of security. The recommendations of this group include:

- Increase dialogue; increase information flow; integrate across scales and concerns by encouraging agencies on both sides of the border to include all stakeholders to resolve conflict among populations, security, and environment/ecosystem services
  - Public participation and input from people on the ground who can identify the specific problem areas for direct solutions; bottom-up, then top-down approach
  - Invest in developing better data for baseline measurements of quality of life; find the equilibrium between population and quality of life to better understand what population size the region can properly sustain
- Draft binational contingency plans for natural disasters and emergencies by setting up the mechanisms and infrastructure for transborder understanding and consultation, including local to federal jurisdictions
  - Preparation, response, and recovery need to be planned and implemented across the border through close binational collaboration and cooperation
  - Natural disasters by 2030 will become more severe and will be aggravated by larger and more vulnerable human populations

  - Preparations for natural disasters are applicable to emergencies caused by chemical spills or terrorism incidents; proper natural disaster planning improves the security of border populations in a number of ways
- Mandate security, preparedness, and emergency response in urban development plans; developers should work with municipalities and planning organizations on both sides of the border
  - Develop vulnerability indicators
  - Zoning and building codes need to be adjusted to the realities of disasters in many U.S. and Mexican border communities
- Preserve, protect, and conserve biodiversity and resiliency of ecosystem services; there is a need to integrate that objective into binational as well as urban and rural planning by enabling local ecological and environmental issues to be raised—also recognizing the connection between urban areas that depend on rural areas for ecosystem services
  - Develop indices for sustainability
  - Develop incentives/payments for protecting intact ecosystems
  - Create more green space in urban areas—reconnect urban populations with nature to encourage future stewardship and improve quality of life
- Carry binational recommendations to all the levels of government and private sector by publishing the proceedings and scheduling briefings to all on both sides—bottom-up and top-down approaches
- Establish a mechanism to monetize impacts, lost value, productivity, integrity, and health costs associated with ecosystem services lost

Border Governance/Infrastructure and Financing

Current border governance lacks an effective framework for cross-border collaboration between the U.S. and Mexico. This stems partly from a lack of widespread understanding and interest in cooperation. Cross-border collaboration is also difficult due to the asymmetries of government structures and the power and authority of different government branches and jurisdictions. The U.S. and Mexico are both federal republics, so there are similarities, but great differences as well. Although there was a positive sense among conference participants that Mexican governance seems to be decentralizing, they noted that there is inadequate coordination in Mexico among different levels of government. Municipalities, although given more leverage than before, still lack the resources to fund domestic as well as binational solutions. In addition, the effectiveness of the Mexican government depends heavily on the person in power— which can change rapidly for better or worse. In the U.S., federal and state authorities, particularly in California, are stepping in and taking over many local level issues because cities lack the funds to deal with them. Federal and state agencies are often less likely to be aware of border realities and to commit resources to cross-border collaboration.

Constructing and financing border infrastructure is equally difficult. Traditional sources of funding, such as the Border Environment Infrastructure Fund, are diminishing. This makes it increasingly difficult for BECC-approved projects to be provided with low-cost financing by the North American Development Bank. New approaches, including public-private partnerships and binational bonding mechanisms, need to be explored and then implemented when useful.

Although transparent and public environmental impact assessments for the transboundary region are conducted for BECC and NADB infrastructure projects, the same is not true for most large infrastructure projects built in the border areas of Mexico and the United States. While transboundary Environmental Impact Statements are consistent with NEPA and LGEEPA, most local, state, and federal agencies as well as private companies take the position that their environmental review concerns end at the international boundary. Breakout session participants and conference attendees were in consensus regarding the importance of developing a viable Transboundary Environmental Impact Assessment (TEIA) process. The shortsighted business-as-usual approach simply ignores transborder spillover effects. Neglecting these transborder implications in the short run can lead to significant conflict in the longer term. Recent examples of large infrastructure projects that rejected consideration of transborder spillover effects yet produced significant levels of conflict include the lining of the All-American Canal, the construction of InterGen's La Rosita thermoelectric plant in Mexicali, and the installation of the border fence and associated infrastructure.

The business-as-usual scenario for border governance and infrastructure in 2030 will miss opportunities for improving trade and regional security. The border will be a jumble of different legal and governance landscapes, with greater disconnect between the two nations as diplomatic and public works funding diminishes. On the one hand, U.S. cities will be to a much greater extent under the authority of state and federal agencies, with more centralized control of resources and planning. On the other hand, Mexican border cities might be more independent of federal control, but without the resources to finance large infrastructure projects. With the local level losing leverage in the U.S., stakeholders will struggle to find ways to empower border cities. If agencies apply similar policies in dissimilar regions (i.e., rural vs. urban), grounded solutions will become more elusive and problems will spread.

A sustainable border region in 2030 will require significant grassroots action to promote and gain widespread support for improving local, cross-border connections. The border region has much to gain from collaboration among "sister cities." Not only would united border metropolises be more competitive against emerging regional economies in Southeast Asia and elsewhere, but also they would be better prepared to address regional environmental and emergency response concerns. The participants of Border Institute X devised a set of recommendations for improving border governance and financing, including the following:

- Build interest and understanding through outreach to elected officials and the citizenry
- Create local and borderwide organizations with stakeholders who have experience collaborating among disparate agencies and can communicate with decision makers
  - Seize the momentum of Border 2012 and continue to coordinate border-spanning treaties and initiatives of the Border Governors Conference
  - Local cooperative bodies, such as SANDAG, are needed to handle regional issues too large for an individual organization; these regional issues are often best handled at the local level

    - Concentrate on practical solutions to specific local problems such as land use or transportation. This type of bottom-up approach to addressing local issues and empowering local governments is likely to be the most effective solution
    - There is a critical need for similar regional planning and governance bodies in Mexican border regions
- Build a better understanding of existing agreements before constructing new ones
  - There are useful mechanisms within the La Paz Agreement that are not used often enough, such as the option to form Joint Advisory Committees
  - The CEC, formed by the NAAEC side agreement to NAFTA, has a mandate to develop a system for applying transboundary environmental impact assessments to each project in the border region—revitalize, perfect, and cooperate to make this diplomatic nicety binding on all parties
  - Employ the Border Liaison Mechanism to facilitate cross-border government-to-government cooperation at all levels
  - Build expertise and devise strategies to implement the standards defined within NEPA/LGEEPA regarding TEIAs
- Study international examples of funding mechanisms
  - Lessons can be learned from the European Union, which funds local-level agencies but does not dominate their actions
- At Border Institute XI, the topic of border governance needs to be given more attention and specific papers commissioned. Topics for discussion include:
  - How are border governance issues dealt with elsewhere?
  - Federalism in the U.S. and Mexico
  - Misunderstood areas of the La Paz Agreement
  - Existing border-oriented groups and their mission and reach

Air Quality, Energy, and Climate Change

The present air quality in the border region has benefitted from past binational engagement, including the successful establishment of Mexican air quality monitoring networks. However, the original funding for this project has ended and the stations are aging and need upgrades. Although the U.S. and Mexico have relatively consistent data within the major binational airsheds, without a new source of funding for Mexico, monitoring air quality in the region is going to be very challenging.

With regard to energy, the breakout group focused on electric power generation. About 80 to 85% of electric generation in the border region is now produced from carbon-based sources (i.e., natural gas, coal, or petroleum). This mirrors the structure of the global energy system. A concern in Mexico is that electricity transmission is inefficient. In the U.S. and Europe, about 7 to 8% of energy is lost through transmission. In Mexico, about 13% is lost. This means that more electricity must be generated and that more pollution will be created.

With a business-as-usual approach in 2030, binational cooperation on air quality will be problematic. Without further attention, collection of air quality data in Mexico may be severely limited and informed policy decisions will become more difficult to make. Harmonization of U.S. and Mexican air standards will also become more difficult, which will hinder binational collaboration on air quality issues. On a positive note, fleet modernization in the U.S. due to new federal laws may reduce VOCs and hydrocarbons. There may be some improvement in air quality with regard to certain pollutants, but not for all pollutants. It is unclear how NO_x and PM might improve. In Mexico, mobile source pollution is the most detrimental to air quality, but it is very difficult to impose vehicle standards or inspection. With an increasing population and vehicle miles traveled, pollution from transportation is likely to increase.

Recommendations to achieve a sustainable border environment by 2030 with regard to energy, air quality, and climate change include:

- Develop a unified airshed management. The U.S. and Mexico recognize binational airsheds but there is no mechanism to enforce rules or coordinate investment in abatement on both sides of the border. This is a difficult task when national sovereignty comes into play. A viable compromise would be to binationally define a set of actions to be undertaken and task local authorities with achieving them.
- Allow for cross-border investments. It is often less costly and more effective to invest in improvements for Mexican infrastructure. For example, diesel buses in Tijuana are older and

pollute more than those in San Diego. Conversion to LNG would reduce pollution more per bus in Tijuana than in San Diego, rendering greater benefits for the entire binational airshed. Other investment priorities include paving of streets and increased availability of public transportation.

- Increase the number of monitoring stations within each air basin and standardize the site selection methodology in order to produce consistent and reliable binational air quality data.
- Continue and expand energy conservation and efficiency. Obvious opportunities include increasing use of insulation and weatherization in residential and commercial buildings to reduce energy demand.
- Localize energy sources. If done properly, energy generation can be a driver of economic development. Energy that is generated locally creates jobs, avoids capital outflows, and benefits from lower transportation costs and reduces loss during transmission. Ideally, energy would be generated locally from a mix of sources, including renewable ones.
- Maximize regional economies by developing cross-border generation, transmission, and refining. Siting of energy facilities should be based on regional economics and resources, not political boundaries. This could be accomplished by creating a binational energy commission charged with planning energy infrastructure consistent with TEIAs and national concerns.
- Address the causes and adapt to the consequences of climate change. Unified energyshed management, increased energy efficiency and conservation, and cross-border investment could all help reduce greenhouse gas production that is related to climate change. If "climate change" is not an actionable topic, link similar policies to reduce greenhouse gasses that can be linked to improving air quality and reducing human health effects from air pollution.
- Create a binational climate change task force under Border 2012.
- Enter into global and regional environmental agreements and take advantage of future carbon-trade opportunities.

OVERARCHING APPROACHES TO ACHIEVING THE VISION

As the rapporteurs presented the breakout session summaries, it was clear that within the recommendations, there were a few reoccurring, big picture ideas for how to achieve a sustainable 2030. Several of these are outlined as follows:

Paradigm Shift: There is a need for public perception to evolve to a point where people are willing to make small sacrifices and commitments in order to conserve resources or reduce pollution. At the same time, managers must begin to allocate resources based on sustainable supply, rather than demand. Ultimately, resource managers should backtrack to the end-user (the environment) and allocate for each user from that point forward. Negative externalities should be used as a metric to determine selection and cost of natural resources used for production. The best way to do this would be to establish a mechanism to monetize impacts, lost value, productivity, integrity, and health costs associated with ecosystem service losses tied specifically to the types of resources being used and how they are being used.

Adaptation and Mitigation: Rather than trying to prevent, mitigate the causes and adapt to the consequences of climate change. Remove financial and legal barriers to cross-border investment in pollution mitigation projects. Localize energy sources. Energy that is generated locally creates jobs, avoids capital outflows, and benefits from lower transportation costs and reduces loss during transmission. Integrate plans for biodiversity and ecosystem protection into urban and rural planning.

Transcending Levels of Governance: Bottom-up approach, local to federal. It is important to build understanding of the border region at all levels of governance. Utilizing the insight of, and allocating resources to, local level government/organizations would create the opportunity for federal and state levels to better appreciate life at the border. Encouraging participation and input from people on the ground who can identify the specific problem areas for direct solutions will make for better environmental and regional policymaking.

Binational Dialoguing and Communication: Create and expand local and borderwide organizations with stakeholders who have experience collaborating among disparate agencies and can communicate with decision makers. Interagency and organizational collaboration should be increased by developing common objectives that are measurable and contribute to the main goal of each of the existing agencies. Work on reframing binational dialogue with a less antagonistic approach. The key question is, how can we manage and care for our joint resources better, rather than just rely on binational adjudication? Build a better understanding of existing binational environmental treaties and agreements before constructing new ones.

Each report out was followed by a question-and-answer opportunity and the conference closed to a round of applause and a sense of mutual satisfaction with the information presented and the productivity of the binational group of border environmental experts. Looking back to the first Border Institute conference, "A Road Map to a Sustainable 2020," the participants produced a vision for a sustainable border region in 2020 that is equally appropriate for the objectives of the Border Institute X conference and a sustainable border region in 2030:

> A healthy, sustainable natural environment with an involved binational community, ensuring proper resources management as a basis for a secure and adequate quality of life for all border inhabitants.

Endnotes

1 SANDAG. Revised working draft of the Regional Comprehensive Plan, p. 196 (2004).

2 SANDAG. 2007 Update: Economic Impacts of Wait Times in the San Diego-Baja California Border Region (Fact Sheet).

3 DHS Press Release. "Action Plan between the Department of Homeland Security of the Unites States of America and the Secretariat of Governance of the United Mexican States to Combat Border Violence and Improve Public Safety." (3 March 2006), http://www.dhs.gov/xnews/releases/press_release_0874.shtm

4 IBWC. Wastewater Treatment Plants. http://www.ibwc.gov/Mission_Operations/Wastewater_TP.html

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The SCERP Mission

The Southwest Consortium for Environmental Research and Policy (SCERP) was established by the U.S. Congress in October 1990 to "initiate a comprehensive analysis of possible solutions to the acute air, water quality, and hazardous waste problems that plague the United States-Mexico border region." SCERP is a consortium of five U.S. universities (Arizona State University, New Mexico State University, San Diego State University, University of Texas at El Paso, and University of Utah) and five Mexican universities (El Colegio de la Frontera Norte, Instituto Tecnológico de Ciudad Juárez, Instituto Tecnológico y de Estudios Superiores de Monterrey, Universidad Autónoma de Baja California, and Universidad Autónoma de Ciudad Juárez). SCERP carries out its mission through a cooperative agreement with the U.S. Environmental Protection Agency. A permanent administration office is maintained by the consortium in San Diego.

The SCERP Solution

SCERP uses a broad, integrated, multidisciplinary approach to address issues related to the environment of the border. SCERP researchers collaborate with the U.S. Environmental Protection Agency (EPA) and Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), as well as local and state governments, tribal nations, business and industry, non-governmental organizations, and communities of the border region. SCERP organizes research, outreach, and training programs devoted to improving environmental conditions and building capacity in the border region for resolving critical environmental problems. SCERP is pioneering a model of binational cooperation that brings U.S. and Mexican researchers together and introduces new skills and perspectives in binational environmental problem solving.

CONSORCIO DE INVESTIGACION Y POLITICA AMBIENTAL DEL SUROESTE

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