Air quality at the US-Mexican border; current state and future considerations towards sustainability

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Abstract

Many border residents are currently exposed to health-threatening levels of air pollution by the presence of substances such as ozone (O_3), particulate matter (PM), carbon dioxide (CO_2), and sulfur dioxide (SO_2). This situation has created concerns on both sides of the border, and the U.S Environmental Protection Agency (EPA) and the Mexico's National Institute of Ecology (Instituto Nacional de Ecologia-INE) have developed regional strategies to improve air quality based on separate but similar national ambient air quality standards.

Air pollutants move freely across political borders. Because of physical conditions such as topography, geomorphology and weather, border communities share air sheds or air basins that are characterized by changing wind patterns depending on the season. Wind is the means of transport of air pollutants, and thus any human activity that generates pollutants on one side of the border will have an impact on the other side.

The objectives of this paper are two-fold: to describe the current state of binational air quality and to analyze what needs to be done to make the environment of the border region sustainable. In order to achieve this twin objective, the present work is divided into five parts.

1. Characteristics of the border
2. Air quality: management and current status
3. Potential air quality issues at 2030
4. Transborder 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 uncontrolled, could present an obstacle for achieving a sustainable environment.

The second part analyzes the main air pollutants in the U.S.-Mexico border region, reports on the current air quality in the border region.

The third part describes the potential issues in 2030 based on emissions forecast and reviews briefly potential to climate change impacts on O_3 and PM generation.

The four part reviews air quality regulations for both countries, and 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 identifies some key issues related the achievement of sustainable air quality in the binational US-Mexican border.

Introduction

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, 1996).

Regions adjacent to international boundaries are likely to be 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

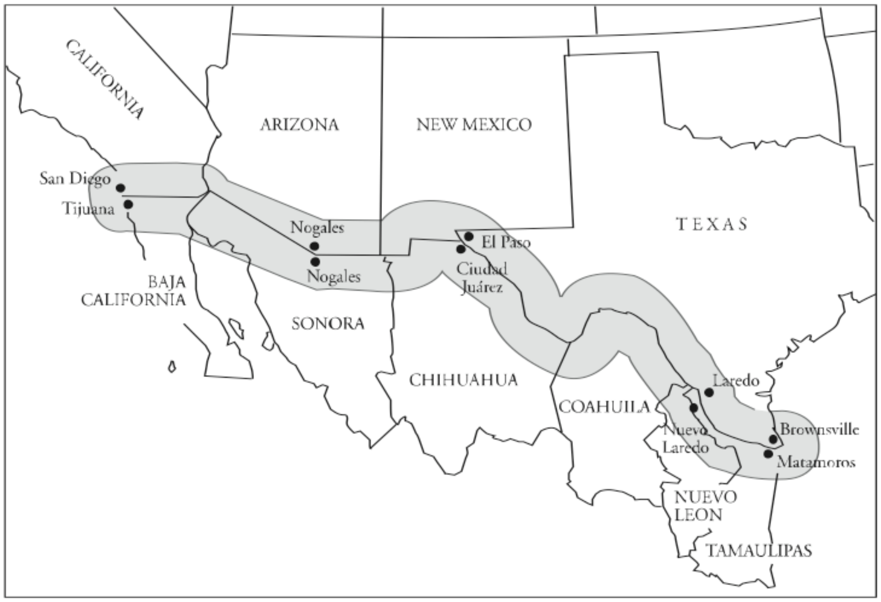
Geographic and economic asymmetries can give rise to transboundary commerce in the form of formal and informal networks for exploiting potentially profitable business opportunities. Political and cultural asymmetries, by contrast, can serve as obstacles to transboundary collaboration. The economics of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

1. Characteristics of the US-Mexican border

1.1. Overview of the US-Mexico border region

The border that divides Mexico and USA has a length of 3141 km. It has as a main objective to be selective to the transit of people as well as trade. This selectivity, however, does not apply to the transboundary air, water and land pollutants at any point of its entire length extending from the Pacific Ocean to the Gulf of Mexico. The Mexican-USA "border region" is defined by the binational La Paz Agreement as the territory situated within 100 km 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 American side; and 35 municipalities in Baja California, Sonora, Chihuahua, Nuevo León, Coahuila, and Tamaulipas on the Mexican side.

This region witnesses a highly complex net of relationships between the two countries, related to sharing natural resources, social and cultural links, and economic transactions. These relationships have not always been voluntary and in some cases have had consequences not intended or fully thought out. This last statement, in particular, describes the relationship that the inhabitants of the border region have with much of their environment, a relationship which at best could be considered problematic given the widespread and often growing deterioration in the border zone.



Source: U.S.-Mexico Chamber of Commerce

Figure 1. The Mexico-USA border region defined by the La Paz Agreement

1.2. Socio-economic aspects of the border area

In 1983 the La Paz Agreement was signed between Mexico and USA to address cooperation for the protection and improvement of the environment of the border region. There were growing concerns over the increasing environmental degradation in the metropolitan zones in the border region; a direct result of accelerated population growth in the absence of well planned development, with 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 supply of water, insufficient or nonexistent sanitation, etc.

Although population growth occurs on both sides of the border, rates have been higher on the Mexican side. The relative number of inhabitants on the Mexican border region rose visibly with respect to the total of Mexicans: 17% in 1930, 3.4% in 1950, 4.9% in 1970 and 5.1% in 1990. This large increase was centered in ten big cities: Ensenada, Tijuana, and Mexicali in Baja California; San Luis Río Colorado and Nogales in Sonora; Cd. Juárez in Chihuahua; Piedras Negras in Coahuila; and Nuevo Laredo, Reynosa, and Matamoros in Tamaulipas. The causes of the population and urban growth of the border region have been not only the birth rates (minus mortality), but for several decades also significant internal migration (Corona, 1991).

Dillman (1983) also determined that the accelerated population growth at the border region on the Mexican side was due to internal migration. Mexicans migrated to the north border because they perceived it as prosperous. However, they considered themselves to be temporarily in the area and on their way to USA. The same author identified the creation of the “maquiladora” (assembly plants) industry program in 1965 as a key economic element that attracted workers to the region.

The industrial development increased even more with the signing of the North American Free Trade Agreement (NAFTA) in 1994. In Mexico, the border region has the lowest unemployment index and highest salaries. Economic growth clearly has generated jobs, but such growth has not been accompanied by a complementary increase in environmental infrastructure 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; it is estimated that this number will double by 2025. Therefore it is a priority to guarantee the wellbeing of inhabitants and their environment alike, requiring that that all future development be not only economically viable but be accompanied by social concerns that additionally consider the sustainable use of natural resources.

1.2.1 Maquiladora industry

Two factors are associated with the initial development of the maquiladora industry in the Mexican border region: the cities' locations and their status as custom-free zones. Thus, the combined effect of being at a long distance from the rest of the Mexican Republic plus the existence of a free zone in the region since the 1930´s, discouraged the establishment of Mexican companies for many years.

Under such scenario, 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 at 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 free zones and national perimeters 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 point due to two factors: 1) the small size of local and regional demand; and 2) the competition with the Chinese market. This new situation poses a challenge to industrial growth in the region, calls for a diversification of the regional economy, and demands that important changes be made in the development and organization of the entire region.

1.3. Geographic characteristics

The geographical characteristics of the border region are such that twin cities share common air basins. As discussed, the border region is experiencing rapid economic and population growth that results in increasing environmental stress that is not environmentally sustainable on either side of the border. Without rapid action, air quality can be expected to deteriorate. The situation requires binational solutions. Officials on both sides of the border have increasingly come to recognize this and are attempting to develop a response. Developing solutions to border air quality problems requires a binational dialog that must involve federal and local officials, non-governmental organizations (NGO´s) and the private sector.

1.3.1. Unified air sheds

The 2006 edition of the Random House dictionary defines an air shed as “a geographical area within which the air frequently is confined or channeled, with all parts of the area being subject to similar conditions of air pollution.” In other words, geography, meteorological forces, climate, and other factors—not political boundaries--define air sheds.

The 1983 U.S.-Mexico La Paz Agreement (more information on this agreement is offered in a later section of this paper) recognized that pollution from each side of the border affects the other side. Plumes of polluted air can begin in a U.S. border city and flow into a Mexican border city and vice versa. Air pollution is *international* problem from both sides’ perspectives. Air pollution cannot be sufficiently mitigated unless policymakers recognize the existence of a binational common air shed and collaborate binationally. (Van Schoik, R., 2007). An annex to the La Paz Agreement in the mid-1990s (more information in a later section) addressed this situation generally and created a specific "study area" in which more intensive collaboration was promoted.

The USA and Mexico should develop an additional amendment to the La Paz Agreement that adds one or more "study areas" and encourages more formal cooperation in those areas.

1.3.1.1. Potential benefits of designating a unified airshed in the Mexicali-Imperial Valley

The identification of a new study area under the La Paz Agreement in the Mexicali-Imperial Valley area would encourage the consideration of several types of binational collaboration and air quality management (AQM) mechanisms.

a) Trading of Emission-Reduction Credits

The "rich country/poor country" dichotomy existing between USA and Mexico makes attractive the possibility of cross-border "trading" of emissions credits in the Mexicali-Imperial Valley. 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 amount of reduction on the Mexican side within a common air shed. 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 economic way to obtain the air quality and public health benefits desired.

Although markets for emission reduction credits are currently possible under certain conditions in air sheds within the USA, 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, and possibly would require an amendment to the Clean Air Act by the U.S. Congress.

b) 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.

c) Cost-Benefit Analyses

Formal recognition of a common air shed 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 will identify those public and private clean-ups that can be implemented most cost effectively, regardless of the location.

d) 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 common air sheds, states could be encouraged to allow for International Supplemental Environmental Projects.

e) Diesel Emission Reduction Collaborative (DERC)

The U.S. EPA’s National Clean Diesel Campaign provides funding in cooperation with varioU.S. 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.

f) Energy Service Companies (ESCOs)

An energy service company, or ESCO, can perform an audit of 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 owner of the facility 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.

g) Renewable Portfolio Standards (RPSs)

All U.S. states have identified target levels of renewable energy (either absolute amounts or percentages of generation capacity) that electric utilities must meet by target dates. These are usually aggressive goals that are intended to force energy providers to diversify their energy sources into alternative fuels. 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 air sheds, 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.

h) Binational Air Council

California State Senator Denise Ducheny has proposed a council that could identify, prioritize, and implement projects and strategies that would result in emission reductions through, bilateral regulations, and incentives. The council would be organized to represent all sectors of the Mexicali-Imperial Valley.

i) Other new and revised AQM strategies

Policymakers, stakeholders, and academics can use the BCA to identify perverse peculiarities in the regulatory structures at and across the international, state and local border.

1.4. Infrastructure at the border

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

1.4.1. Street paving

One of the main environmental problems at the border region is high PM concentrations. A significant source of PM is the category of unpaved roads on the Mexican side. Some border states such as Baja California have addressed this problem. For example, in 2003 the Direccion de Ecologia Estatal (now the Secretaria de Proteccion al Ambiente) de Baja

California worked with SEMARNAT and the Border Environment Cooperation Commission in a successful effort to obtain financing that included the North American Development Bank (NADB).

1.4.2. Brick kilns

In Ciudad Juarez 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 emit large clouds of soot, carbon monoxide (CO), NOx, and volatile organic compounds (VOCs).

Roberto Marquez of New Mexico Sate University, with funding 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. 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.

In a unique cross-border trading situation, the Texas legislature passed a law 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 Cd. Juárez. El Paso Electric 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.

1.4.3. Ports of entry

There are 39 ports of entry, with a total number of lines allocated as follow: 73 for pedestrian crossing, 215 for passenger vehicles, and 83 for commercial trucks.

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

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

Table 1. Average waiting time, minutes

	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: Ports of entry US-Mexico

Congestion causes additional costs to trade. For example the annual direct costs of 745, 975 vehicles waiting for three hours is 139,870,200 dollars annually, or 466,236 dollars per day.

2. Air quality: current status, trends, and issues (through 2030)

Air quality is degraded by the presence of pollutants. Air pollutants are substances that, in high enough concentrations, harm human health, and sometimes also harm other parts of the ecosystem or materials. These pollutants are quite diverse but can be classified or characterized in several ways, including by physical or chemical characteristics, by source, by fate, and by affect.

With regard to physical characteristics, 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 characteristics 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). 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 affects on human health (pollutants leading to ozone depletion and greenhouse gases are the prime examples).

Given the ample range of air pollutants, their sources, nature, and effects, it is of fundamental importance to adopt efficient systems of regulation and management of air quality (Farmer, 1997). Typical management approaches in the United States and Mexico involve several sets of activities. Chronologically, the first set of activities is the identification of the affects 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 may be threatening. After determining which areas are violating 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 we know about the current status of air quality in the border region, are explained in more detail in the subsequent sub-sections.

2.1. 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 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 Normas Oficiales Mexicanas (NOM), 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, sulfur dioxide, lead, and nitrogen oxide. Because of the particular criteria used to identify these pollutants—principally based on health affects—these are called the criteria pollutants.

Mexico has also identified the the same criteria pollutants and established 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 affects 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. NAAQS 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. In addition there are secondary standards that are set to protect public welfare, including protection against decreased visibility, and damage to animals, crops, vegetation, and buildings. There are three differences between primary and secondary NAAQS: 1) there is not a secondary standard for CO in either of the two averaging times; 2) there is not a secondary standard for hourly averaging time; and 3) the secondary standard for SO_2 is 0.5 ppm (1300 $\mu g/m^3$) and it is set only for an averaging time of 3 hours.

The second aspect of the U.S. NAAQS meriting explanation is the “attainment” concept. A geographical area in which the measured concentrations of pollutants meet all the NAAQS is considered to be in a status of attainment. An area in which the measured concentrations do not meet one of the NAAQS in designated to be in non-attainment status for the particular standard. An area may be in attainment status for one pollutant standard and in non-attainment status for another. In addition, the *extent* to which a particular standard is violated (the severity of the violation) can lead to an additional level of designation, using the terms marginal, moderate, serious, severe and extreme. Non-attainment areas will have to implement different control measures, depending upon this additional classification.

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 more strict over the past 20 years. Modifications in U.S. NAAQS have usually come first, followed over time by modifications to the Mexican NOMs (the development of $PM_{2.5}$ standards has been a prime example).

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-range transport (via wind) of that category of pollutants, rather than local emissions. This aspect of air quality management is pertinent to Big Bend National Park in the border region of Texas.

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

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

Sources: U.S. Environmental Protection Agency; and Mexico Secretaría de Protección de Medio Ambiente y Recursos Naturales & Secretaria de Salud

Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air (µg/m^3)

The regulatory function is of course country-specific, but air pollution has been historically acknowledged as one of the most important binational issues in the border region. It has received explicit attention in the form of binational treaties and programs, and this context is explained in more detail in section 4. But the following sub-section looks more closely at one aspect of that cross-border collaboration—the regional air quality indicators that have been developed cooperatively.

2.2. Border indicators of air quality

The current U.S.-Mexico binational environmental program is called Border 2012. 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 uses indicators to track general environmental conditions and trends and to evaluate the affect of the implementation of specific projects. In a “State of the Border 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

In 2008 this report was updated. Data were added for 2006 and 2007 and indicators were re-evaluated. Two refinements were proposed:

A) Removing the indicator related to the prevalence of Physician-Diagnosed Asthma in Calexico/Mexicali. Despite the abundance of information regarding asthma prevalence, a comparison was not possible due to the lack of a common format. Both countries and even border states have differences in reporting mechanisms and disease's definition.

B) Including additional indicators of air quality such as the existence of emission-reduction strategies, greenhouse gas emissions, and results of specific emission reduction projects.

Three of the indicators of border air quality are based on direct measurement of ambient concentrations by monitoring stations over a seven-year period in five geographic areas where there have been monitors on one side or both sides of the border: 1) Tijuana/San Diego, 2) Mexicali/Calexico, 3) Nogales/Nogales, 4) Cd. Juarez/El Paso, and 5) the Lower Rio Grande Valley (the southeast corner of Texas). Data have shown that the most persistent and pervasive pollutants found in the border region are ozone and particulate matter (PM_{10}), as seen in Figures 2 and 3, respectively.

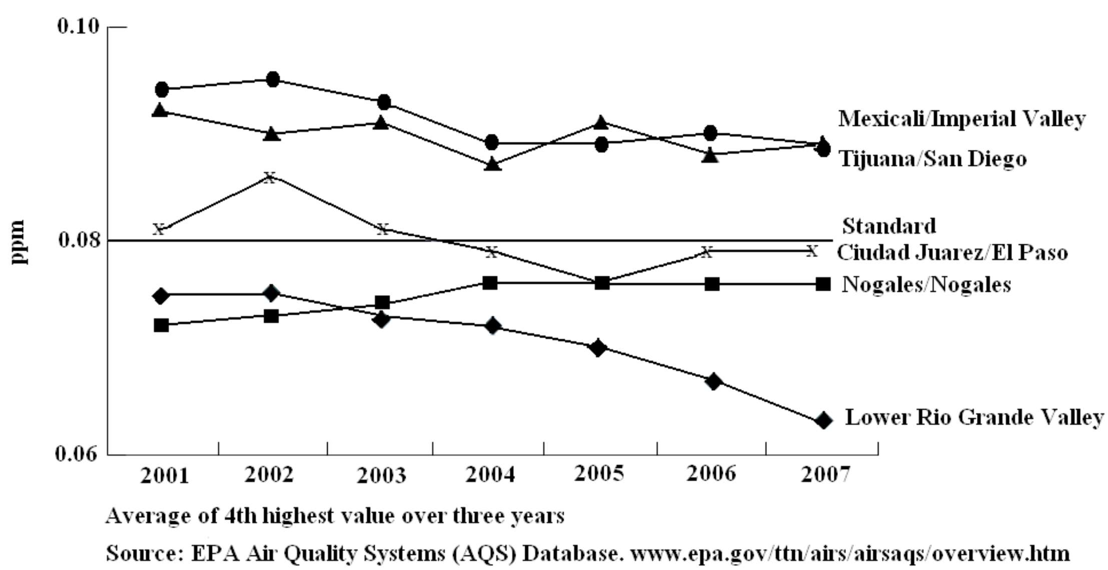


Figure 2. Averaged ozone concentrations in the border region

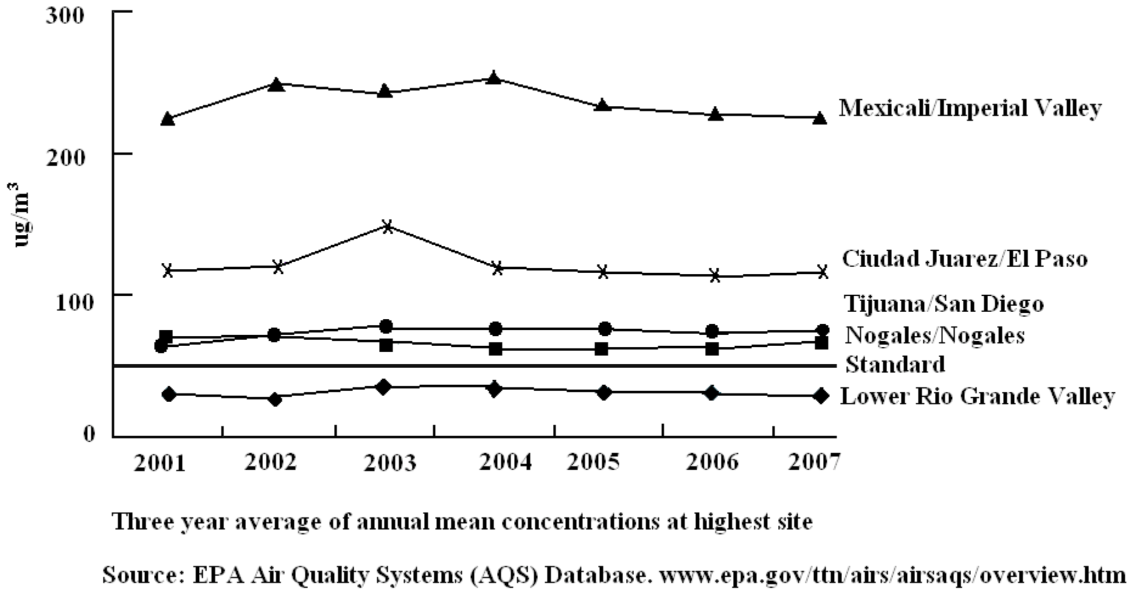


Figure 3. Averaged PM_{10} concentrations in the border region

2.3. Attainment status in the border region

Because of the nature of air sheds, 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 non-attainment status can be interpreted from this perspective. Figures 2 and 3 show how air quality in selected border air sheds 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 2) and Mexicali/Imperial Valley has had the most severe problem with PM_{10}, followed by the Ciudad Juarez/El Paso region in Chihuahua/Texas. The Nogales/Nogales area in Sonora/Arizona has a less several 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 air sheds, reflecting the relative numerical values shown in Figures 2 and 3, and adding information about sulfur dioxide (SO_2) in one of those air sheds and the problem of visibility in Big Bend National Park.

Table 3. Non-attainment status of air sheds in the border region

Air shed	**O_3**	**CO**	**PM**	**SO_2**
San Diego/Tijuana	8 hrs			
Imp. Valley/Mexicali	Marginal (1 & 8 hrs)		Moderate	
Douglas/Agua Prieta			Moderate	Primary
El Paso/Cd. Juarez	Under review		Moderate	
Big Bend Park Region	Visibility concerns			
Lower RG Valley				

Source: Currey B.

As discussed, the designation of an area as non-attainment 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 sub-sections.

2.4. Air quality management in the border region

Three of the important sets of activities undertaken for air quality management are ambient monitoring, the development of emissions inventories, and modeling. EPA and SEMARNAT have, to varying degrees, made use of all three tools to identify both problems and possible control strategies.

2.4.1 Monitoring

According to the Sistema Nacional de Información de la Calidad del Aire (SINAICA) of Mexico, 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 Cd. Juarez). In addition, the U.S. EPA has supported monitoring stations in three municipios in Sonora—San Luis Río Colorado, Nogales, and Agua Prieta—as part of binational studies.

In contrast, the EPA's ambient air quality monitoring program is delegated to the states, and 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)—measures ozone precursors (approximately 60 volatile hydrocarbons and carbonyl) was required by 1990 amendments to the Clean Air Act.

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

2.4.2 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 of their respective 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:

1) Point sources (this is defined as stationary sources with emissions above a certain threshold, and includes 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, wildfires, etc.);

3) Mobile sources (this is usually divided into on-road mobile sources, such as vehicles, and non-road mobile sources, such as airplanes, ships, and mobile equipment used on farms); and

4) Biogenic sources (pollutants emitted by plants)

2.4.2.1. Mexican Border States

In 2005 the Instituto Nacional de Ecologia unveiled the first air emissions inventory for the six Mexico border states (the IEEFN), using a base year of 1999. This baseline emissions inventory was developed to increase the understanding of emissions sources located in Northern Mexico and to support air quality assessments. IEEFN is a product of binational government partnerships completed through collaborative efforts between the United States and Mexico.

IEEFNE 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 annual metric tonnes, of which 88% came from natural sources and 46 % specifically in Chihuahua.

Emissions of CO totaled 1,264,500 annual metric tonnes; 73 % of these emissions came from on-road vehicles circulating in Nuevo Leon. PM emissions, including $PM_{2.5}$ and PM_{10}, totaled 1,059,300 annual metric 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 important in Nuevo León.

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

2.4.2.2. U.S. Border States

EPA is 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. 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 NOx are released during fossil fuel combustion—principally vehicle engines, power plants, and boilers. In addition, VOC sources include vapor release during handling of fuel storage and the use of solvents. The main source of SO_2 is the combustion of those fossil fuels have high sulphur concentrations. PM is also emitted during fossil fuel combustion, although additional important 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 fraction of Pb 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.

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.

2.4.2.3. 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 lately Yuma/San Luis Río Colorado.

The Ambos Nogales inventory showed that the majority of the emissions come from area sources rather than point sources, with engine exhaust from vehicle traffic as a major source 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 lead came primarily from road dust stirred into the air by vehicle traffic. The majority of the chlorinated chemical emissions came from industrial facilities. Household chemical use contributes to the emissions of hazardous chemicals. A higher number of point sources exist in Nogales, Sonora due to the presence of maquiladoras. Nogales, Sonora had higher lead emissions from lead soldering operations at the maquiladoras; and also had higher emissions levels than Nogales, Arizona for the 25 chemicals studied.

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

2.4.3 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. But it is equally clear that many air-related problems in the region persist.

In other words, the efforts to date have been insufficient, reflecting the complexity of the challenge and all its social, economic, and political aspects. Resolving air quality problems will require re-doubled efforts at all levels of government, in the private sector, and in terms of binational collaboration. In addition, both nations and the border states should not limit their actions only to narrow and direct air pollution issues, but look for a holistic approaches for air quality management that tackle issues related to the larger context, which includes the socio-demographic aspects that were identified in section 1.

With regard to binational collaboration, it is again fair to note that much has 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 fair to add that many more actions are urgently needed.

The next section of this paper examines trends that can be anticipated over the next 20 years.

3. Potential air quality issues through 2030

The previous sub-section presented a description of the current status of the 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 growth generally has a negative impact on air quality. This is particularly relevant for the border region because of shaped its rapid industrialization rate, changes in land use patterns, and growth in population and transportation (including international trade). But as also seen, environmental regulations and control of air emissions are already playing an important role 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?

There are many factors that affect future emissions, but essentially they are a function of change in activities (growth or decline) combined with changes in the emission rate or controls applicable to the source. 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. Nonroad mobile source projections are also based on modeling. Saying this is important to consider that future changes in activity level are not only explained through sophisticated modeling, actually the most common and simplistic method is through the use of extrapolations of collected historic data.

Future projection or forecasting of air quality could provide stakeholders with information useful to define mitigation actions, and to inform the population. The two largest U.S. border states—California and Texas—have prepared air emission forecasts up to 2020 and 2040, respectively (Texas only with respect to on-road mobile sources).

3.1 Air quality forecast in California in 2020

Air quality forecasts to the year 2020 based on 2008 data are detail in “The California Almanac of Emissions and Air Quality” 2009 Edition (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, forecasted emissions are presented.

The purpose of this section is not to replicate the in-depth information contained in the ARB Almanac but to extract selected facts 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 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.

Table 4. California estimated emissions to 2020, (ton/day, annual average)

Year	**ROG**[1]	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Population**	**VMT**[2]
2010	2127	2981	10543	294	2139	682	39135677	958079
2020	1950	2173	8369	394	2275	707	44135923	1104522

[1] Reactive Organic Gas A reactive chemical gas, composed of non-methane hydrocarbons that may contribute to the formation of smog. Also sometimes referred to as non-methane organic gases (NMOGs)

[2] Avg. Daily VMT/1000

As seen in Table 4, PM as PM_{10} and $PM_{2.5}$ emissions are forecasted to increase to 2020. Both emissions will have as dominiting sources area-wide sources, with other area-wide sources contributing in nearly 85 % and 67% to PM10 and $PM_{2.5}$, respectively. See Figure 4a and 4b.

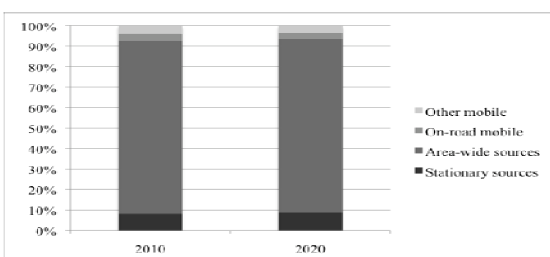


Figure 4a. Forecasted source contributions to PM_{10}

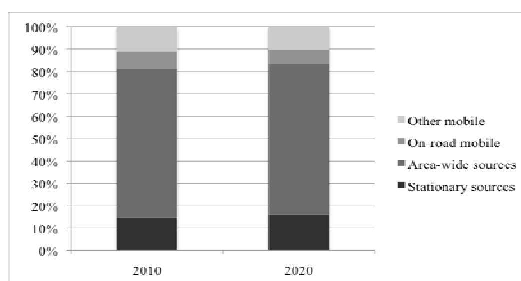


Figure 4b. Forecasted source contributions to $PM_{2.5}$

In forecasting ozone, it is important to remember that this pollutant is not emitted directly, but formed by chemical reaction of other air pollutants. Therefore, to have a better idea of the concentrations of ozone in the futu, one needs to pay attention to the principal precursors, NOx and VOCs. Table 4 indicates that both categories are forecasted to be reduced 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 phenomena could be quite relevant.

Finally, Table 4 shows that CO is forecasted to become the main pollutant in California. This emission 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 other mobile sources will increase its importance, especially those using gasoline fuel. See Figure 5.

3.2. Air quality forecast in Texas in 2030

The Texas Transportation Institute (2008) prepared a study for the Texas Commission on Environmental Quality that provided year-by-year estimates of total vehicle emissions based on the expected result of existing control programs. These estimates do not take into consideration any new technologies that may emerge or any significant switch by citizens to more efficient passenger vehicles.

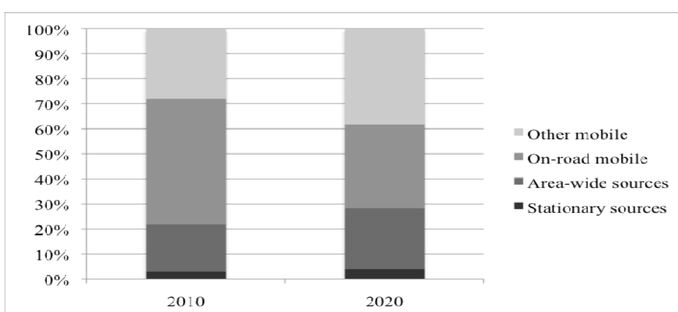


Figure 5. Forecasted source contributions to CO emissions in California

The Texas estimates shown in Table 5 indicate that despite increase in population and increase in vehicle miles traveled, the emissions for some pollutants will go down, and for others will not go up as much as one would otherwise predict from "business as usual" combined with increases in population and VMT.

Table 5. Texas On-Road Mobile Source Emissions Forecasts (ton/day)

Year	VOC	NO_x	CO	SO_2	CO_2	$PM_{2.5}$	Population	VMT[1]
2010	162298	362222	2375792	2669	152948893	6713	24330612	258434265295
2020	96101	113401	1988061	2679	178947272	4496	28005788	303161637950
2030	93005	88586	2170459	3076	205078265	4897	31830589	348355780270

[1] Annual Vehicle Miles Travelled

3.3. Future of the air quality of the border region to 2030

Data from California and Texas could be used as good 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, with over 4.5 million people. The next largest sister-city pair is El Paso/Ciudad Juarez. In addition, two of the ten fastest-growing metropolitan areas in the United States—Laredo and McAllen—are located in the Texas border region. Currently there are no emission forecasts for the future for New Mexico, Arizona, or the six Mexican border states.

Based on the estimates presented in the two previous sections and considering population growth and historical trends of air quality problems in the border region, one can conclude that continuing and increased attention must be focused on air quality and the development of strategies for sustainable development.

3.4. The possible impacts of climate change on air quality

As mentioned, forecasting emissions can provide information useful for designing mitigation strattegies. But the estimations are only as good as the parameters and assumptions being used. This task is already complicated enough, but in the past couple of decades there has been emerging information about the possible affects 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, as rising temperatures and shifts in cloud cover that affect the formation of pollutants such as ozone and increasing emissions of pollutants from fires, dust, and vegetation.

In 2009 the U.S. EPA released a report entitled “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 out 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. 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), although significant uncertainties remain. The potential impact of climate change on PM is less well understood.

The relevance of these considerations is significant for the U.S.-Mexico border area, because ozone and PM are the primary pollutants concern in the region. In addition, future climate estimates indicate that it is quite likely that by 2080, and that rainfall will decrease to 0 to 0.6 mm/day (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. In addition, 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 such increased 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.

4. Historical and Current Transboundary Cooperation

Cooperation on air quality issues between the United States and Mexico, among the ten border states (four in the United States and six in Mexico), and between sister cities on both sides of the border presents a number of interesting challenges. Air pollution doesn't recognize the borders, and so the local residents have common air sheds with sources of pollution on both sides. There are two different legal and political systems and two languages.

Generally, the people of the two countries have not considered the situation to be adversarial and 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.

4.1. La Paz Agreement

The legal framework for most cooperation between the United States and Mexico on environmental topics is the La Paz Agreement,[1] signed in that city in Baja California. That agreement, among other things, stated that each country would identify a national coordinator and that they would hold annual meetings. The document has since been amended to provide for specific actions related to air quality.

[1] The formal name of the La Paz Agreement is the "Agreement between the United States of America and the United Mexican States on Cooperation for the Protection and Improvement of the Environment in the Border Area." For the full text of the agreement, see http://www.epa.gov/usmexicoborder/docs/LaPazAgreement.pdf.

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 then required the Working Group to meet on a "regular basis."[2] Annex most immediately 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 perform a broader purpose.

Annex V, signed in 1989, addresses the "international transport of urban air pollution" more generally.[3] This annex describes a series of actions related to monitoring, emissions inventories, and modeling that each country will undertake in any designated "study areas." It also states that the two countries will attempt to "harmonize" their air pollution control standards and their ambient air quality standards, and will 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 Cd. Juárez, Chihuahua -- El Paso, Texas – Doña Ana County, New Mexico area, "for the purpose of developing and presenting recommendations to the Air [Quality] Work[ing] Group."[4] This committee has come to be called simply the JAC, and is described in more detail in a later sub-section of this chapter.

[2] Ibid., page 16.
[3] Ibid., page 18.
[4] Ibid., page 21.

4.2. 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 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-NADB family focused its attention on projects related to drinking water supply, wastewater treatment, and waste disposal, in 2002 air quality was added to the eligibility criteria. Since then, projects related to the paving of roads, renewable energy, and other air quality-related infrastructure have been assisted.

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

Influential in a different way has been the Arizona-Mexico Commission, a public-private partnership created more than 50 years ago, and its sister entity the Comisión Sonora-

Arizona. These organizations include the environment under their purview, and their assistance on air quality will be addressed in a later subsection on Arizona-Sonora.

Finally, the EPA has used one additional avenue to facilitate 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 emission inventories, to work with Mexico's National Ecology Institute (part of SEMARNAT) on the first comprehensive emission inventories of Mexico's northern border cities. These were published in

4.3. Multi-Media Programs Derived from La Paz and the Role of Air Quality

Under the La Paz Agreement, the two countries have developed three successive, multi-media, and multi-year 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, called Border XXI, was implemented from 1996 through 2000. The current program, initiated in 2003, is called Border 2012, with the title denoting the "end" year.

Each of these programs has had a border-wide 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 it 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 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 region (known as the Four-State region), because of its relatively large geographic expanse and the number of municipalities involved, has created three sub-regional geographic task forces that in turn have created topic-specific committees.

None of the local areas in the Four-State region are in violation of their respective federal air quality standards, and for this reason two of the three task forces in the region have not created air quality committees. The Gulf Task Force (covering the Lower Rio Grande Valley, from 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.

4.4. Operationalizing International Cooperation at the Local Level

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. 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 border area.

4.4.1. 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 Cd. 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 begun earlier in the decade by 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-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. Air quality activities in those two 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 non-attainment for federal standards for ozone, carbon monoxide, and particulate matter. After showing improvement, it has been re-designated as attainment for ozone and carbon monoxide over the past five years, but a reversal of the ozone redesignation is expected as the result of a newer and stricter standard.

The JAC is composed of ten persons from each country. It includes federal, state, and local officials from both sides, plus. non-governmental sectors, both for-profit and not-for-profit. Most participants and observers believes 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 Texas

Commission on Environmental Quality 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 an ongoing sharing of information and ideas, participated in various sub-committees, and 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.

Because of 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 challenge has ever been formally codified was in the JAC's “One Basin Resolution,” which the body passed in 2002. This resolution called for as coordinated management as possible across two countries and three states with regard to (a) a definition of the physical boundaries of the airshed; (b) standardized monitoring and data dissemination; (c) standardized emission inventories; (d) joint modeling; and (e) “harmonized" standards and control programs. None of these is easy in the international context, nor can be accomplished quickly, but participating agencies have been making a good-faith effort to work toward those objectives.

Four specific examples of collaboration 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 Cd. Juárez and then trained Juárez municipal staff on maintenance and operation. Second, the Texas Commission on Environmental Quality installed technology that allowed for radio transmission of the 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 law in Texas resulted in more stringent pollution control limits for an electric utility serving El Paso, Texas also passed a law allowing such a utility to meet its reduction requirements by engaging in a cross-border "trade," i.e., financing a reduction on the other side of the border. The utility complied by paying for conversion of brick kilns in Cd. Juárez to a much less polluting production technology.

Fourth, the U.S.-Mexico 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 Juárez.

4.4.2. Arizona-Sonora

Cross-border cooperation in the Arizona-Sonora region has involved several of the enabling institutions mentioned earlier.

The Arizona-Mexico Commission as its sister organization the Arizona-Sonora Commission (as introduced earlier) played an important role in assisting EPA and Secretaría de Medio Ambiente, Recursos Naturales y Pesca (Semarnap) in development of a collaborative effort to study air quality in three sister-city pairs beginning in 1995.

The studies, all funded by EPA, started in Nogales, Arizona and Nogales, Sonora (the two are referred to as 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 emission 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 measuring only particulate matter. Both Nogales and Douglas, Arizona are in non-attainment 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.

The third similar study has been conducted more recently 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.-Mexico border, and is expected to be completed in 2006. Yuma is in non-attainment 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.

Since 2004 the Ambos Nogales area has received funding from various sources to address air quality issues. In 2004 the Sonoran community obtained financing from the NADB in 2004 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 the Ambos Nogales area.

In a third example, three task forces of the Arizona-Sonora Commission (air, water, waste, 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 that can in turn be blended with regular diesel to produce a cleaner fuel. The idea was subsequently funded as a project by 2008.

Finally, ADEQ and its counterpart, the Sonora Commission of Ecology and Sustainable Development (CEDES), share air monitoring data.

4.4.3. 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 is 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 non-attainment status for their respective national ambient standards for ozone.

The only other 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 non-attainment status. under the U.S. 8-hour ozone standard and under the particulate matter standards (both PM_{10} and $PM_{2.5}$). []

Officials in this area had created an air quality task force in about 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. The principal air quality problems are particulate matter and ozone.

As with the JAC, both these task forces serve principally as forums for exchange of information, dialogue, and identification of possible strategies for implementation by participating or other agencies. The task forces themselves have no budgets and do not implement programs or projects.

Both these 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 Border Environment Cooperation Commission.

Various combinations of agencies (federal, state, and local) cooperate in several activities. One example is the operation and maintenance of the northern Baja Air Quality Monitoring Network, and a second is emission inventories for Mexicali and Tijuana. Other examples are 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 State Environmental Agency and SEMARNAT twice a year to review the progress of those projects that are jointly implemented in this region.

5. Observations and recommendations

This chapter showed that air pollution is still one of the most important issues in the U.S-Mexico border region, in particular due to high concentrations of ozone and PM_{10}; despite of the received attention in the form of binational regulations and cooperation. There is a need for a better monitoring, characterization of sources and understanding of the climate change processes influencing air quality. But most importantly, growth in the border region has to move forward of being in fragile balance with air quality, to follow a permanent pattern of sustainable development.

References

Bell ML, McDermott A, Zeger SL, Samet JM, Dominici F. 2004. Ozone and short-term mortality in 95 U.S. urban communities, 1987 – 2000. Journal of the American Medical Association 292(19): 2372 – 2378.

Chock DP, Heuss JM. 1985. Urban ozone and its precursors. Environmental Science and Technology 21(12): 1146 – 1153.

Corona R. V. 1991. Principales características demográficas de la zona fronteriza del Norte de México. Frontera Norte, Vol. 3, num. 5, Ene.-Jun. 1991.

Cox P., Delao A., Komorniczak A., and Weller R. The California Almanac of emissions and air quality. 2009 Edition. Planning and Technical Support Division. California Air Resources Board. Available on line at:
http://www.arb.ca.gov/aqd/almanac/almanac09/almanac2009all.pdf

Dillman, C. D. (1983). Border urbanization. In E. Stoddard, R. N. Ellwyn, R.

Erickson, D.A., D. Molina, and S. Ghosh, 2004. The U.S.-Mexican Border Environment: Improving Transboundary Air Quality with Binational Emission Reduction Credit Trading. SCERP Monograph Series, No. 10, San Diego State University Press, San Diego, California.

Farmer A., 1997. Managing environmental pollution. Routledge. London, UK. Pg. 58.

Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F.

Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Fuentes N. A. et al. 2007. "U.S.-Mexico Ports of Entry: A Capacity Analysis and Recommendations for Increased Efficiency," El Colegio de la Frontera Norte, Tijuana, December 2007.

Halvey, R. , 2002. *Border Congestion, Air quality, and Commerce*, in Both Sides of the Border, Transboundary Environmental Management Issues Facing Mexico and the United States , Linda Fernandez and Richard T. Carson (Eds), Kluwer Academic Publishers, The Netherlands, pp 281-322.

Hansen, Niles. 1996. "Barrier effects in the U. S.-Mexico border area In New Borders and Old Barriers in Special Development. Peter Nijkamp, ed. Brookfield: Avebury.

INE-SEMARNAT, 2006. México Tercera Comunicación Nacional ante la Convención Marco de las Naciones Unida sobre el Cambio Climático.

Nostrand, and J. West (Eds.), Borderlands sourcebook: a guide to the literature on northern Mexico and the American southwest, pp. 237-244. Norman, OK: University of Oklahoma Press.

Rick Van Schoik, 2007, Clarification letter to Ned Strong, Manager of LASPAU, March 23, Cambridge, Mass

SEMARNAT and EPA, 2006. Border 2012: U.S.-Mexico Environmental Program Indicators Report 2005. Available on line at: http://www.epa.gov/usmexicoborder/indicators/05report/SBR_2005_English.pdf.

The Texas Transportation Institute, 2008. On Road Mobile Sources Emissions: Trends for all 254 Texas Counties: 1990 through 2040. Texas Transportation Institute, The Texas A&M University System, College Station, Texas.

USEPA, 2008. U.S. Environmental Protection Agency web page: http://www.epa.gov/usmexicoborder/bordermap.html. Last updated on Monday, November 17th, 2008.

Wise E. 2009. Climate-based sensitivity of air quality to climate change scenarios for the southwestern United States. Int. J. Climatol. 29: 87 – 97.