

Desertification in Tijuana (Mexico): Effects and Policies



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1. Introduction

Almost a quarter of a century ago, scenes of tens of thousands of people dying of starvation in the African Sahel captivated the human race. A prolonged drought at the end of the 1960s and early 1970s, on top of a long history of resource mismanagement and unsound policies, produced the most striking episodes of famine, images of which reached virtually every home in the Western Hemisphere. The diagnosis issued at the time focused mainly on the extended drought, although other factors like population growth, the persistent use of fires to promote new vegetation growth, and the agricultural extension of cash crops rather than food production were also recognized. But the most important outcome of the Sahelian tragedy was that it unveiled to the world the “insidious environmental plague called *desertification*.” (Thomas and Middleton, 1994).

As a direct result of the Sahelian episode, the United Nations Conference on Desertification (UNCOD) convened in 1977 in Nairobi, in the headquarters of the United Nations Environment Program (UNEP). The United Nations Plan of Action to Combat Desertification (UNPACD) resulted from the conference, composed of four parts. First, a world map of desertification, or more accurately, a map of desertification hazard; second, a review of key themes needed to understand desertification and its causes; third, six case studies commissioned in various parts of the world and affected by a different set of factors; fourth, the feasibility studies on the means for combating desertification in a transnational framework¹. Since the international community began its initial efforts to combat desertification, the phenomenon has more and more been associated with human mismanagement. Though there are many definitions posted in the literature², the concept of *desertification* has shifted accordingly with the newer understanding of its causes.

This essay discusses the effects of desertification in Tijuana, Baja California, Mexico, a highly urbanized area of the U.S.-Mexican Border that sits adjacent to the North American drylands. Unlike the bulk of literature on desertification, it addresses the issues that are highly relevant to urban rather than rural populations and argues about its importance on a global scale. Tijuana is a city of approximately one million inhabitants that straddles the international border, south of the sprawling urban area of San Diego, California. It is the seventh largest city in Mexico (INEGI, 1995), one of the fastest growing in the country, with intense economic activity and an almost non-existing unemployment rate. Its dynamic economy and its proximity to Southern California’s economy has made Tijuana a popular destination for north bound migrants from inner Mexico; it is also a frequent crossing point for undocumented immigration.

The development of Tijuana in general has historically followed the growth of trade and services, but also, over the last decade, of rapid industrialization. In turn, land development has become critical, prompting a pattern of rapid and incomplete urbanization that has resulted in many subdivisions without services (unpaved streets; no water, sewage, parks, or open space) and a lower environmental quality. Given Tijuana’s low annual precipitation and high evapotranspiration rates, the arid conditions and poor air quality discussed above prevail over the course of the year. Eolic erosion takes hold during the summer months and hydrologic erosion in the winter months; both, in equal measure, constitute major causes for great expense to the municipal government for sediment collection and control in streets and rain collectors, as well as street sweeping and maintenance in general. In addition, misguided policies by local authorities for vegetation conservation/urban reforestation provide little relief in offsetting this adverse set of conditions.

¹ Thomas and Middleton (1994), p.4.

² Glantz and Orlovsky (1983) identified over 100 definitions that appeared in the literature.

In this initial section we will look at the definitions of desertification, review the institutional framework that developed on a global scale, and briefly visit the occurrence of desertification in the northwestern part of Mexico. The second section looks at the differences of the phenomenon between its occurrence in rural, agriculturally based areas with the issues relevant to cities. The third section focuses on the conditions in Tijuana, reviewing the causes and effects of soil degradation and desertification taking place locally. The closing section examines Tijuana's local policies and programs aimed at increasing vegetal cover in the city and explores alternative options for controlling desertification in Tijuana and other similar cities in dry areas of the developing world.

Desertification: Definitions and History

Mainguet (1994) describes the different circumstances under which processes of land degradation or desertification occur, and associates them with the definitions that have been developed by several authors in the past. The idea of desertification resulting from an "encroaching desert" was developed by Frank Cana (1915) and Bovill (1921), and was in vogue prior to the UNCOD; even today it remains a myth for many national governments. A second conceptualization was grandfathered by Mabbutt (1978), and is represented as a continuum of change in "the character of the land to a more desertic condition" involving "the impoverishment of ecosystems as evidenced in reduced biological productivity and accelerated deterioration of soils..." A third view emphasizes the long-term effect, and the "chronic and pervasive" consequences of the phenomenon, and has been best described by Street (1987) and Kates et al. (1977). The fourth meaning, as described by Hare (1985), refers to desertification as simply the loss of resilience of ecosystems, and hence their incapacity to "revive and repair themselves" (Mainguet, 1994).

The original definition that resulted from the UNCOD in Nairobi read:

Desertification is the diminution or destruction of the biological potential of the land, and can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems, and has diminished or destroyed the biological potential, i.e., plant and animal production, for multiple use purposes at a time when increased productivity is needed to support growing populations in quest of development.

A decade later, Ahmad and Kassas (1987) would point out that despite the increased awareness and publicity that derived from the 1977 UNCOD, global figures on desertification remained unabated. Six million hectares – or 60,000 km² – were being lost annually to the phenomenon, and as many as 20 million hectares were being reduced to zero or negative productivity on a yearly basis. Their description of the problem was more precise and their definitions a bit more varied. Desertification was a "process of environmental degradation by which productive land is made non-productive and desert-like." Also, desertification was "a global environmental problem that affects some 100 countries directly... essentially due to interaction between societal systems and fragile ecosystems..."; the process was associated with misuse and over-use of land resources"... with "no evidence that desertification is caused by large-scale climatic change" (Ahmad and Kassas, 1987).

For Mainguet (1994), however, neither of these definitions favors the understanding of *causes or mechanisms*, nor helps distinguish them from *manifestations or the actual impact* of desertification. She suggests the following definition:

Desertification, revealed by drought, is caused by human activities in which the carrying capacity of the land is exceeded; it proceeds by exacerbated natural or man-induced mechanisms, and is made manifest by intricate steps of vege-

*tation and soil deterioration which result, in human terms, in an irreversible decrease or destruction of the biological potential of the land and its ability to support population.*³

Table 1: Suggested root causes of land degradation and desertification.

Natural disasters	Degradation due to bio-geophysical causes or 'acts of God'
Population change	Degradations occurs when population growth exceeds environmental threshold (Neo-Malthusian) or decline causes collapse of adequate management.
Underdevelopment	Resources exploited to benefit world economy or developed countries, leaving little profit to manage or restore degraded environment.
Internationalism	Taxation and other forces interfere with market, triggering overexploitation.
Colonial legacies	Trade links, communications, rural-urban linkages, cash crops and other 'hangovers' from the past promote poor management of resource exploitation.
Inappropriate technology and advice	Promotion of wrong strategies and techniques which result in land degradation.
Ignorance	Linked to inappropriate technology and advice above: a lack of knowledge leading to degradation.
Attitudes	People's or institutions' attitudes blamed for degradation.
War and civil unrest	Overuse of resources in national emergencies and concentrations of refugees leading to high population pressures in safe locations.

Source: Thomas and Middleton (1994), p.85.

Thomas and Middleton (1994), on the other hand, focus on the causes of desertification and affirm that if solutions are to be found, "the focus of attention must be on human actions." A comprehensive list of suggested causes of desertification is shown in Table 1.

Current Institutional Framework

The United Nations' Conference on Environment and Development (UNCED) – the Earth Summit – called for a convention to renew the efforts to combat desertification that began in Nairobi in 1977. In the context of increasing concern over global environmental issues and the renewed discourse on sustainable development, the parties to the convention stated:

"Appreciating the significance of the past efforts and experience of States and international organizations in combating desertification and mitigating the effects of drought, particularly in implementing the Plan of Action to Combat Desertification which was adopted at the United Nations' Conference on Desertification in 1977,
Realizing that, despite efforts in the past, progress in combating desertification and mitigating the effects of drought has not met expectations and that a new and more effective approach is needed at all levels within the framework of sustainable development,
Recognizing the validity and relevance of decisions adopted at the United Nations' Conference on Environment and Development, particularly of Agenda 21 and its chapter 12, which provide a basis for combating desertification, ..."
 (UN, 1994).

³ Emphasis added.

In other words, the world community, in 1992, decided to place the problems of desertification on the *train* of sustainable development and link its implementation to the international structure offered by the Agenda 21 framework. An example of this can be appreciated as we examine desertification in the case of Mexico and, in particular, the city of Tijuana.

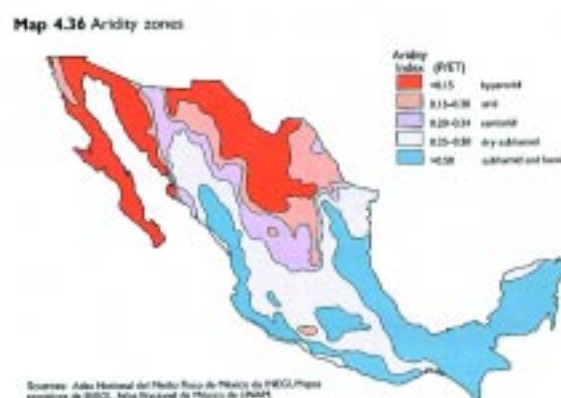
Ultimately, the Convention on Desertification was officially opened for signature on October 14, 1994 in Paris, and signed into effect by 116 countries on December 26, 1996. A Conference of the Parties was established as the supreme body of the Convention, with a Permanent Secretariat and a Committee on Science and Technology as other governing bodies, and an open coordination of activities with other UNCED conventions (Climate Change, Biological Diversity).

Desertification in Mexico

Mexico's natural environment is largely dominated by drylands. According to the country's National Commission for Arid Zones (Comisión Nacional de Zonas Áridas), more than 60 percent of Mexico's territory is severely affected by land degradation, and over 260,000 hectares of grazing and arable land are taken out of production annually (UNEP, 1997). Physical processes (eolic and hydrologic erosion), biological processes (loss of soil micro-organisms), and chemical processes (loss of nutrients, salinization) are the main promoting agents of this land degradation, mostly in the highly susceptible drylands (arid, semiarid, and dry-sub-humid), where the precipitation to evapotranspiration (P/ET) ratios fall below 0.5 as an index (Figure 1).

Human activities also play a big role in land degradation. Deforestation, excessive grazing, overcultivation, and overpumping of aquifers are cited as the most common causes ⁴. Moreover, Liverman (1992) warns of the particular vulnerability of Mexico's environment with respect to global warming and other climatic changes occurring. The most conspicuous dangers lie in the northern part of the country, in places like Chihuahua and northern-Sonora, where "temperature increases in the already hot summers are likely to bring great stress to humans, plants, and animals, especially if these monthly averages imply even higher daily extremes."

Figure 1. **Map of aridity zones in Mexico. Border areas in the north appear more susceptible to land degradation.**



As in the rest of the world, the literature on desertification in Mexico (Liverman, 1990; Liverman, 1992; Liverman and O'Brien, 1991; UNEP, 1997) focuses on the effects of desertification in rural agricultural areas. But land degradation and desertification are equally problematic in cities. In particular, the northern part of Mexico has several cities

⁴ Schwartz and Notini, 1995, cited in UNEP, 1997

along the U.S.-Mexican border that fall within the arid and hyperarid areas of the country shown in Figure 1. Tijuana is the most conspicuous of these border cities, because of its size, its growth rate, and its limited water supply. Before proceeding with a discussion on the case of Tijuana, we will look at desertification in cities in a broad and general way.

2. Desertification in Cities

As previously pointed out, one limitation of the literature on desertification is its treatment of the phenomenon as virtually an exclusive problem for global food sufficiency and agricultural production in rural areas. The reasons for this may be twofold. First, desertification and land degradation in general is a qualitative assessment on the biological productivity of soil, which is closely tied with the food production capabilities of land. Second, the most glaring social consequences of an impoverished soil up to date has been the famine experienced in many parts of the world where land degradation has taken hold. For example, Mainguet's (1994) discussion of the topic includes Sub-Saharan Africa, Egypt, and China; and while two of the largest cities (Cairo and Peking) settled in drylands are contained in these regions, her discussion totally avoids mention of the plight of urban dwellers caused by desertification. In a similar vein, Thomas and Middleton's (1994) discussion refers to the desertification effects that urban life causes on rural areas (increased pressures on agricultural fields and deserts), but not on the effects on urban life itself.

However, many cities in the Southwestern United States and Northwestern portion of Mexico lie along the North American drylands (Sheridan, 1981), and suffer the effects of land degradation due to urbanization and urban practices in general. The main characterization of these effects includes:

- a) Great disturbances in native vegetation caused by urbanization patterns, and so,
- b) A high percentage of barren land or land sparsely covered by annuals;
- c) Severe changes in the local hydrology caused by impervious surfaces and changes in the topography that promote water erosion in places haphazardly;
- d) A high percentage of unpaved streets, all of which leads to
- e) Poor air quality with a high rate of suspended PM-10.

Cooke et al. (1982) compiled a list of 355 cities of over 100,000 inhabitants in drylands throughout the world. Heading the list are cities like El Cairo and Alexandria in Egypt, Peking and Tientsin in China, Teheran in Iran, and Los Angeles (USA), Santiago (Chile), and Lima (Peru) in the Americas. At the top of the list of "growth rates for selected dryland cities of 100,000 or more inhabitants" in the Americas is our case-study city, Tijuana, which annually grew during the 1960s at an amazing 11.9 percent. Though that incredible growth rate has decreased since, the city continues to expand at a healthy 5.8 percent per annum, a little under three times the national population growth rate of Mexico⁵.

An important distinction, however, is in order, between dryland cities in the United States and those in the Third World. While all dryland cities suffer from water limitations, many industrious urban centers in the U.S. (e.g., Phoenix, AZ; Las Vegas, NV) are founded on an economic activity that allows the expenditure of resources (imported water, power for climate control, exotic vegetation, etc.) to mitigate the desertic conditions of their chosen settlement. When referring to the case of the U.S., Mainguet (1994) prefers the term "dryland degradation" rather than desertification, "because the richest country in the world has the technical and financial solutions for the rehabilitation of its degraded areas."⁶ As expressed by Sheridan (1981), "(the) term *desertification* sounds odd in an American context."

⁵ Percentage corresponds to the growth from the 1990 Census of Population to the 1995 Population Count by INEGI.

⁶ Mainguet, p.129.

Third World cities are in a different set of circumstances altogether. Thirty-one percent of Mexico's urban population lived in arid zones in 1970, and 35 percent of urban places were settled in drylands. The quest for agricultural land as a historical means of subsistence, plus the vast extents of drylands within the Mexican territory has been a major determinant in dryland settlements within the country. Mexico is among the top two or three countries in terms of annual growth rate in drylands population. Only India exceeds Mexico in the number of dryland cities within the developing world; in 1982, India had 62 cities over 100,000 inhabitants, and Mexico had 22⁷.

Causes and Effects of Desertification in Cities

Dryland areas of the world are highly susceptible to climatic changes due to the absence of moisture in the atmosphere that can buffer temperature variations. In addition, the sparse vegetation that typically exists in drylands offers little relief to intense radiation, strong winds, or the occasional events of heavy precipitation and flooding. This was evidenced in the recent effects suffered in Lima, Peru as the El Niño phenomenon hit the western coast of the Americas, causing severe flooding and disaster to several cities.

Moreover, dryland degradation occurs almost as a consequence of urban growth. Urbanization patterns tend to clear native vegetation and replace it with impervious material (roads, sidewalks, gutters and storm-sewers, or buildings). The hydrology of the city is changed, with concentrated flows causing erosion, nutrient leaching into groundwater and/or nearby waterways. This, in turn, results in impoverished soils that become even less apt at supporting any efforts of replanting perennial vegetation, like native (or even exotic) trees or shrubs, wiped out by urbanization.

Vegetation is a big factor in making cities livable. Vegetation sequesters air pollutants, rendering cleaner air; it holds rainfall in the foliage and increases the porosity of soil, thus reducing runoff, reducing water pollution, and preventing floods. By increasing the local evapotranspiration rate, it cools down the area, thus reducing the energy costs of cooling buildings and food and other perishable supplies. Without vegetation, dryland cities become not only less comfortable (temperature extremes, no shade, greater air pollution, less greenery) but also more vulnerable to floods and other common natural disasters.

3. The Case of Tijuana

Tijuana is the northwestern-most city in all Mexico, bordering the Pacific Ocean to the west and the United States of America to the North (Figure 2). Its location is better explained as a historical-cultural accident than as a product of nature. Slightly over a century old, the city has always been water limited; it was formed as a small agricultural valley that quickly became a service town for both visitors from the U.S. naval base in San Diego, California, as well as the immigrants from southern portions of Mexico looking for work beyond the international border. Amidst the clash of two cultures, two economies, two nations, Tijuana-San Diego are the largest twin-cities in the U.S.-Mexico border, and symbolize the neighborhood of the industrialized and the developing world better than any other place in the globe.

⁷ As a reference, the United States had 42 dryland cities at the time (Cooke, et al., 1982).

Figure 2. **Map of the U.S.-Mexico Border in the Tijuana-San Diego Border Region**



Source: de la Parra and Luecke (1996).

The natural environment in Tijuana is not unlike the description of drylands discussed so far in this essay. The average monthly temperatures range from 44 degrees F (8 C) to 75 degrees F (23 C), the annual precipitation rate fluctuates between 170 and 280 mm (average = 240 mm), all of which falls from November through April, and the potential evaporation rates surpass the 2000-mm mark on average on a yearly basis⁸. The natural vegetation of the region is described as Coastal Scrub (Coyle and Roberts, 1975), slightly different than the woodier, more common Chaparral of further inland. The prevailing winds come from the Pacific Ocean virtually year round, on-shore winds in the morning and offshore in the afternoon, and seasonal easterly winds that blow on occasions from the desert and mountainous regions of the east, locally known as a Santa Anna weather condition.

The Tijuana River, which originates in the mountains some 85 km southeast of Tijuana proper, crosses the city and divides it into a southwest/northeast split; on the eastern portion of the urbanized area it joins the Alamar River, which comes from the U.S. part of the Tijuana River basin. Within the urban area, the channeled river collects urban runoff, besides conveying the base flow of the river and aquifer during wet periods. The river crosses into the United States some 5 to 6 km before hitting the ocean, and empties into a salt-marsh estuary that has been designated as an ecological research reserve by the U.S. Federal Government.

Tijuana's urban area spans more than 30 km inland and covers an area of more than 19,000 hectares on a steep/hilly topography, with an average population density of 37 inhabitants per hectare. Tijuana's growth as an industrial center, its miniscule unemployment rate, and its strategic location for potential U.S. immigrants makes the city an attraction pole for the labor market, which in turn has made the real estate market in the city very dynamic. New housing subdivisions of various income brackets are continuously being developed, though squatter or irregular settlements characterized by incomplete urbanization are a continuous occurrence in the city. The irregular settlements lack the proper urban services,

⁸ Data were taken from the National Weather Service's figures for the weather station in Chula Vista, CA, (<http://www.wrcc.dri.edu/summary/climsmsca.html>).

like running water or sewage collection; in addition, no landscape design has been incorporated into the housing plan. Without running water or a proper design for vegetation within that space or their lifestyle, the new settlers live under dire living conditions and with chronic health problems in the long run.

Many regular and irregular settlements⁹ exhibit improper planning, having overlooked the precarious stability of land in many parts of the city, or the extraordinary amounts of rainfall and runoff that occur on occasions. These settlements become an obstruction to the runoff-currents or the object of landslides, and are ultimately a life hazard to the residents. Two recent El Niño events in the last five years have demonstrated the precariousness that many new settlers in Tijuana live in. As we shall see in our analysis of the 1993 event, the plight of these residents is strongly associated with land degradation.

Urban Vulnerability

In January 1993, a 14-day storm hit the Pacific coastline, precipitating 210 mm over Tijuana in the two-week period, 50 mm alone in a continuous 24-hour event. Hydrologic erosion quickly began to occur, and currents of sediment-laden runoff like a mud-slurry began to reach the streets. To the dismay of the local population and authorities, the storm sewers were proving insufficient to convey the slurry, which caused the streets to flood and literally paralyzed the city's regular activity for the 14-day period. The emergency response crews were equally focused on rescuing residents from the rivers of mud, the landslides, and the flooding as on removing tons of consolidated sediment from the storm sewers, in preparation for a more extended period of rainfall or a second storm.

In the aftermath of the storm, it became clear that a major problem in the drainage capacity of the storm-sewer system was the systematic build-up of sediment that had accumulated over the years from one minor rain event after another. The consolidated nature of this sediment had forced the municipal government to break open the streets, uncover the culverts, and use heavy equipment to remove the sediment. The signs showed that years of erosion and sedimentation had prevented the urban infrastructure from working to its complete capacity.

A second analysis of the disaster was performed on the dynamics of the geomorphologic processes (erosion, soil shifts, redepositing, and flooding) that took place during the 14-day event (Bocco et al., 1993). Using aerial photography and its interpretation, the study concludes that 1960 hectares (ha), more than 10 percent of the urbanized area, experienced severe soil shifts: 1120 ha suffered erosion, 380 ha suffered the redepositing of the eroded material, and 460 ha experienced flooding. Close to 80,000 people were identified as directly affected, and more than 40 people lost their lives during the ordeal.

Analysis of the Events

The storm that hit Tijuana during the first week of January 1993 has changed the population and the authorities' perception of the risks this city is subject to in the event of a storm. The storm preparedness of the city has since been improved upon by a diligent and consistent program of sewer maintenance, particularly when the wet season draws near in the closing months of the year. And while this program preserves a certain margin of maneuverability for storm events, it does little to reduce the level of vulnerability the city is in.

The critical issue in Tijuana remains the level of neglect the environment is in, as society and government jointly define their development priorities. Native vegetation has been all but obliterated from the natural landscape to make way for streets, housing subdivisions,

9 The terminology of regular and irregular refers to the legal procedure through which housing divisions must pass. The irregular settlements are first created on the ground by the residents or a spontaneous land broker as a response to a social need for housing and then legalized on paper and updated before the cadastre office.

shopping centers, or industrial complexes. The natural soil in the hillsides of the valley is being eroded away and stripped of its already poor level nutrients gradually by air and water. Land is being used to erect new housing complexes, without any regard for properly incorporating vegetation to make the development friendlier, provide shade to reduce the sun's radiation, or to promote the development of plant roots to hold the soil in place.

The same neglect for the environment that has stripped the city of its native vegetation has created the conditions of high vulnerability in which the city is in today. That same neglect is now fostering conditions for further land degradation and desertification. And though Tijuana does not depend on the richness of its soil for the food intake of its population, the impoverishment of its soil will reduce the likelihood of urban greenery thriving in places throughout the city, with severe consequences imposed on people's security, overall solace and quality of life, the quality of the air in the city, and the level of expenses covered by the municipal government for preventative maintenance of the city's infrastructure. Figure 3 shows the typical eroding slope to the side of many urban roads within Tijuana that are permanently threatened by erosion or landslides.

While land degradation/desertification around urban areas is mostly described as a sum process of individual actions, in the case of Tijuana it can be argued that neglect for the environment or an underestimation of its importance to society is a major determinant of the status quo. Thomas and Middleton have referred to underdevelopment as one of many "structural forces at work" that lead to desertification¹⁰. They posit:

Resources exploited to benefit world economy or developed countries, leaving little profit to manage or restore degraded environment.¹¹

As in many overexploited rural areas, it can be argued that the growth rate of Tijuana, which is directly associated with the labor-structure design for a globalized economy, is overexploiting land to the extent that the current development model promotes an imbalance between caring for the environment (land) and using it as a mere factor of production. It is a fact¹² that urbanization in Tijuana is replacing native vegetation with roads and buildings, causing soil erosion and soil impoverishment to an extent that is limiting its natural capability to support vegetation. It is also a fact that a vegetated/forested environment is badly needed to reduce the level of vulnerability the city is currently in, as well as to improve the quality of life of its the residents.

Nelson's (1988) definition of desertification, coined for the World Bank, implies a "reduction in the productive potential of soil to an extent which can neither be readily reversed by removing the cause nor easily reclaimed without substantial investment."¹³ The definition appears to apply very adequately to the growth dynamics in the case of Tijuana.



Figure 3: Typical denuded slope alongside an urban road that is in constant danger of eolic as well as hydrologic erosion. (Road that leads to airport from bus terminal.)

¹⁰ Thomas and Middleton, op. cit., p.84.

¹¹ See Table 1 of this essay.

¹² As exhibited by the study by Bocco et al. (1993).

¹³ Thomas and Middleton, op. cit., p.10.

Government Programs

Mexico is a signatory country to the UNCED Convention on Desertification. But the main efforts to combat desertification at the national level are, again, focused in rural dryland areas, where soil erosion, salinization, and other similar processes are rampant. The Mexican Federal Government's main instrument is the National Program for Reforestation, known as *Programa Nacional de Reforestación* or PRONARE. This federal program is coordinated by the Secretariat of the Environment (SEMARNAP), with the participation of three other federal agencies, the state governments, and social organizations throughout the country. Its main purpose is to increase the vegetal cover in the country by restoring degraded ecosystems through the planting of properly selected species for each region (PRONARE, 1998). PRONARE's main courses of action and promotion include:

- *Production* of agro-forestry projects, commercial, and intense management plantations;
- *Restoration and protection* of areas previously disturbed and degraded by fires, natural phenomena, or land-use changes;
- *Conservation* of threatened and endangered species in order to maintain biodiversity (natural protected areas);
- *Recreation*, which includes urban reforestation in parks, traffic circles and central strips, sporting fields, housing units, etc.

All efforts to restore vegetation in urban areas fall under this last course of action. Throughout the country, the various federal and state agencies operate approximately 611 nurseries that in 1998 will produce 274 million individual plants, mostly trees; the state governments are contributing with 65 million plants, mainly through the work of the local or municipal governments themselves.

At the local level, PRONARE in Tijuana is implemented through a para-municipal agency called the *Sistema Municipal de Parques Temáticos de Tijuana* (Municipal System of Thematic Parks) or SIMPATT. This agency manages *Parque Morelos* and *Parque de la Amistad*, the two largest parks in the city (60 hectares and 24 hectares respectively), but is also responsible for administering federal funds devoted to producing native species in a locally operated nursery at Parque Morelos¹⁴. The actual on the ground planting is performed through a multisectorial committee instated at the request of Mexico's Federal Government: the *Comité Municipal de Forestación (CMF)*. This committee involves the State Government of Baja California, Tijuana's Municipal Government, the private sector (business and industry), the social sector (local NGOs), residents or *colonos*, and academia. The CMF currently relies on 4 nurseries (one operated by a state agency, one by a municipal agency, one by the *Centro de Enseñanza Técnica y Superior (CETYS)* – a private university, and one by the *Asociación Adán* – a local non-profit) funded in part by PRONARE for the supply of plants required by the planting program.

Local Strategies and Perceptions

The basic role of the CMF is to act as a forum to channel requests and concerns over forestation activities in the city. The main active agent in planting and forestation in Tijuana is the city's Department of Parks and Gardens (DPG). This office is under the Directorate of Public Works and Services and the Under-Directorate of Services. The main agenda for the DPG is to (1) maintain the close to 60 *neighborhood parks* that exist in the *colonias* scattered throughout the city, and (2) increase and maintain the urban greenery in the common areas along urban roads and boulevards within the city. Their first task allows city government

¹⁴ SIMPATT has a total of 136 field workers employed, out of which only 13 are devoted to collecting seeds in the outskirts of the city and operating the nursery at P. Morelos. The federal funds it receives from PRONARE are exclusively devoted to the activities of native plant propagation. (Phone conversation with C.P. Jesús Jiménez Rendón, Director SIMPATT, December 14, 1998.)

to meet their obligation of maintaining the city's infrastructure the moment they begin collecting property taxes from the newly created subdivision. For the residents of these *colonias*, their neighborhood park fulfills the need for open space, a bit of greenery in an otherwise arid environment, a playground for children, and in general a place for solace and relaxation. The second task is associated with the urban image that the city instills on visitors and residents alike. The maintenance of urban greenery presumably creates an impact on tourism and on the potential for new investments to take root in the city; it reflects on the local administration, and it certainly influences the voters when local elections come around.



Figure 4. A typical example of urban greenery created alongside urban roads.

For local officials, increasing the amount of *green space per capita* is the ultimate parameter, and there is little distinction if the area happens to be a central strip of a boulevard, the sides of an on-ramp to a speedway, or a neighborhood park in a newly established *colonia*. According to the head of DPG, the parameter in 1992 was a dismal 0.9 m²/capita, but is now estimated to be 3 m²/capita¹⁵. In the view of city government, the gardening around avenues and streets embellishes the infrastructure so painstakingly constructed with taxpayers' money, and helps preserve it from sediment eroding away from central strips or from slopes cut alongside roads (Figure 4).

A third source of green areas for the city are the new subdivisions being built, where the owners are required by law to set aside and equip 3 percent of their saleable land as an urban park. These parks are typically small, from 5,000 to 10,000 m², and some as small as one-thousand square meters (an area of 30 meters by 33 meters). Five to ten new parks every year are turned over to City Government for maintenance and care of the vegetation, as responsible real-estate developers comply with the "3% rule."¹⁶ However, many developers have managed to avoid complying with the state's regulation on neighborhood parks, and so many residents who are feeling cheated from their green space will resort to city government requesting assistance in making the proposed park a reality. This creates a competition for scarce municipal funds between the many different possibilities of determining what type of green area the city decides to plant. Table 2 summarizes the different ways in which parks and gardens are created in the city, and the motives of the party that promotes their creation.

¹⁵ Apparently the target figure is 8 m²/capita. Personal interview with Constantino Seamanduras, an architect who was recently named the Under-Director for Public Services in the City of Tijuana and was formerly the head of Parks and Gardens. October 17, 1998, Tijuana.

¹⁶ DPG currently employs 70 field gardeners/care takers for the 60-plus neighborhood parks. As the number of parks grows at a rate of 5 to 10 parks annually, the labor force must grow also at about 1 to 1.5 employee per new park.

Table 2: Types of forestation initiatives and actors involved.

Type of Action	Purpose/Motive	Promoter
Forestation of common areas	Embellish roadworks Urban image	City Government
Creation of neighborhood parks	Relaxation and solace Sporting field for youth Improve microclimate	Neighbors (colonos)
Forestation of slopes in new subdivisions	Comply with State regulations (3% rule)	Land developer
Forestation of slopes on roadsides	Prevent sediment on paved road	Government agency

4. Analysis of Policies

There is an apparent mismatch between the ecological role that vegetation can play in the interactions that occur in urban settings between the social and the natural systems and the perception of this role for the local authorities in Tijuana. Though city government officials appear quite concerned over the amount of vegetation in the city, their approach to managing the urban environment appears limited. Vegetation is a desirable component within a natural system as a factor of stability; it interacts with soil, air quality, water quality, and helps maintain the nutrient and energy flow of the system. The forestation approach by the authorities in Tijuana is seeking these benefits only partially.

Tijuana's government has concentrated on creating isolated patches of vegetation throughout the city; with this approach, the potential benefits of vegetation are diminished and only reflected in the specific sites of these patches. Vegetation communities and associations yield greater benefits as their extension increases and the border effects are minimized. Greater retention of soil and buffering of heavy precipitation (water accumulation in leaves, greater infiltration) reduce the erodibility of a landscape and, in turn, reduce its vulnerability and propensity to flooding and landslides. Moreover, the current degree of changes in land use patterns within the Tijuana River Watershed call for an all out effort

to preserve the native vegetation as much as possible. According to Ojeda (1998), the "critical point for planning and conservation appears to be when the landscape remains with 60% to 90% of its area with natural vegetation." The Tijuana River Watershed is precisely at that stage.

Healthier and higher-quality¹⁷ vegetation communities within the city of Tijuana will greatly contribute to preserving the ecological integrity of the whole watershed. In that respect, a distinction must be made between *green areas* and what the City of Tijuana Government refers to as *parks and*



Figure 5. A well forested center strip in Boulevard Insurgentes in Tijuana.

17 The concept of ecosystem health is a condition whereby the common nutrient and energy cycles are present; ecosystem quality implies health and a biodiverse and natural state, where many other attributes are still present. (L. Ojeda, personal interview, 17/10/98, Tijuana.)

*gardens*¹⁸. Therefore, in order for the *green areas per capita* parameter to cause an appreciable impact in the meaningful social problems of environmental nature that Tijuana faces today (vulnerability to natural events, public health, quality of life), a change in the forestation strategy must be implemented. A new strategy would consist of focusing on the denuded hillsides and canyons throughout the city and engaging in an effort to restore the native vegetation to as close to its original state as possible. This implies a long-term strategy that includes extensive research in landscape ecology and natural resource management. It implies being able to merge these theories with the dynamics of an urban population that is aggressively growing and in constant change.

The city of Tijuana is an excellent illustration of the dual role that vegetation plays within cities and the need to combine them into one integrated strategy. Figure 5 shows a section of the central strip of Boulevard Insurgentes, illustrating the two possible foci of attention within an urban forestation strategy: on the left, the Boulevard's center strip carefully manicured; on the right, a denuded hillside with evidence of rampant soil degradation.



Figure 6. A typical hillside in Tijuana showing the effects of soil degradation and the infrastructure created to minimize erosion by channeling runoff away and into the local storm drainage system.

The picture illustrates the limited extent to which the current forestation strategy in Tijuana has addressed this duality; and while planting vegetation for reasons of ornament and urban image is not critical, not addressing the ecological role of vegetation is.

Consistent with the philosophy illustrated in Figure 5, Figure 6 shows that in many cases the strategy is completely the opposite of ecological reasoning: while center strips are lushly vegetated, canyons are left denuded, and only the symptoms are treated to minimize the impact on urban life.

In many ways, the desertification phenomenon in cities encompasses many of the environmental variables we have discussed so far in this essay. It is, therefore, an excellent indicator also of the adequacy or inadequacy of the forestation and conservation strategies in place in any city. To the extent that vegetation holds soil in place and reduces erosion, nutrients are retained and recycled within the system, which in turn is better able to support vegetation. A healthy urban vegetation community can reduce the vulnerability of the city to extreme weather variations, control for both air and water erosion, and directly impact the area's air and water quality. In short, though desertification is closely associated with rural areas and food production, a reasonable argument can be made for examining desertification, its causes and effects, in urban drylands.

In the closing section we discuss how an alternative strategy might be better suited to respond to the social and ecological needs of reducing desertification/land degradation in Tijuana and other similar cities.

18 The term green areas has been used interchangeably those of urban greenery or urban parks. However, in this instance, we use "green areas" to mean greater extension of native vegetation either natural or managed, with functions similar to those attributed to green belts or environmental corridors.

Controlling Desertification: an Integrated Approach for Cities

When it comes to promoting vegetation to control land degradation, the major problem of dryland cities is water. Water in dryland cities is generally speaking imported to the region, and in any event, should be used frugally so not to transfer many of the environmental problems to other regions. The obvious approach to forestation needs of dryland urban areas is to reuse the water.

Wastewater reclamation is an old concept that for a variety of reasons remains under-exploited. In particular, wastewater (treated or not) irrigation is used in many dryland areas throughout the world, but more so in developing countries. The typical application for municipal sewage or wastewater is agricultural irrigation, even in places where agricul-

ture has been relegated to a marginal or minimal role within the economic activity of the region (Figure 7). Less common is the reuse of water for urban applications, like industrial needs, or landscape irrigation like golf courses or urban parks. And the concept of using reclaimed wastewater as a resource within an integrated management scheme has probably never been practiced.



Figure 7. Impromptu cornfields that develop alongside Tijuana's wastewater effluent canal.



Figures 8 and 9. Ecoparque, prior to and after 5 years of slope irrigation.

A major requirement of a generalized urban wastewater reuse system is to have multiple points of treatment; this is known as a *decentralized* wastewater treatment system. The reason for this is that the alternative of treating wastewater in one site and then distributing the treated water to the application sites requires more energy, more maintenance, and more infrastructure. But the major obstacle to decentralized wastewater treatment has been the high degree of mechanization present in wastewater treatment technology as well as the cost of wastewater technology. In order for decentralized treatment to be feasible, a change must take place in the technology used¹⁹.

El Colegio de la Frontera Norte (COLEF), a Mexican regional research institution began the study of a Decentralized System for Wastewater Treatment and Reuse (SIDETRAN) in 1986. In 1991, a working model of the technology began operation, reclaiming 90,000

19 See, for instance, Luecke and de la Parra (1994), and de la Parra (1989).

gallons of wastewater every day for the purpose of irrigating and stabilizing the surrounding hillsides. In 1993 it was christened as *Ecoparque* with a broadened agenda of not only reclaiming wastewater but also researching the effects of revegetating hillsides with native species, and serving as a meeting ground for nature and society by promoting environmental education and public participation in local environmental issues. Figures 8 and 9 show the site of *Ecoparque* as seen from a far in 1988 and 1998 respectively.

The central feature of *Ecoparque* is a wastewater reclamation system that treats wastewater through gravity flow, without any additional energy required. Using appropriate technology, one that meets the cultural, technological, and educational characteristics of the country being used. Figure 10 shows an inside view of the complex showing the last of the treatment components (a clarifier) as well as a closer view of the irrigated slopes. The contrast in the color and the texture between the irrigated slopes and those that are beyond the limits of *Ecoparque* illustrate the difference in vegetation that can be attained with constant irrigation.

There are several other characteristics of a model such as *Ecoparque* that make it a promising approach to combating desertification in cities. First, it is located in a highly visible south-facing slope in Tijuana, and is therefore the object of popular curiosity. Second, this high visibility has made it an exemplar of proper integrated resource management for urban areas in drylands, and a stimulus for environmental education at many levels. Third, this in turn can help intensify the cooperation of civil society in the endeavor, as well as future partnerships with other sectors of society. Fourth, being under the auspices of a research institution ensures that a strong applied research component will guide the technological innovations developed.



Figure 10. **View within *Ecoparque*.**

5. Conclusion

The worldwide combat against desertification has had a major emphasis in controlling the phenomenon in rural dryland areas of the world, where food production is of great concern. In this essay, we have illustrated the case of Tijuana, Baja California, Mexico, as a rapidly growing city in the North American drylands that is showing serious effects of desertification in a different manner. Despite having an adequate institutional milieu to promote urban forestation, the results of such efforts point to the need to devise a different strategy, given the environmental conditions of the area and the social impact that natural, although extraordinary, phenomena can cause.

The innovative strategy that is recommended is one which treats the forestation approach to cities with an ecological emphasis, incorporating an integrated resource management strategy to the plan, like wastewater reclamation, in order to meet the limited availability of water in drylands.

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