USE AND LAND TENURE CHANGE IN THE
CHIHUAHUAN DESERT ECOREGION

Discussion Paper prepared for the World Wildlife Fund
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A. Introduction

Land use and land tenure are important influences on biological diversity in the Chihuahuan Desert ecoregion. The conversion of forests and natural grasslands to grazing or cropland alters the habitats of many species. Irrigation of drylands or drainage of wetlands also transforms the ecosystem in ways that affect biodiversity. The intensification of agriculture through increased use of agricultural chemicals poses pollution risks. Industrial developments such as mines and smelters can result in vegetation loss and pollution. Urban development encroaches on natural and agricultural ecosystems. Changes in land use and management are being driven by a range of social factors including demographic, political, technological and economic conditions, especially changes in agricultural policy.

The goal of this background document is to describe the present state of land use and land tenure in the Chihuahuan Desert region as defined by the WWF biology workshop and the major socioeconomic forces that are driving changes in the region. Major land cover types (forest, pasture, irrigated and rain fed cropland) and land uses (crop, types, forest product use) are described as well as patterns of public and private land uses including federal state and local government, ejidos, and private sector. The use of resources on public lands (grazing, timber, traditional resource use, and mining) will be described. The paper reviews important historical processes such as Mexican land reform, US public land policies, and changing agricultural policy and markets. One important objective of this paper is to geographically disaggregate the patterns and processes of land use and land tenure so as to indicate the range and variety of socioeconomic pressures on Chihuahuan Desert biodiversity. The goal is to provide a variety of ideas to stimulate discussion at the fall workshop.

For the purposes of this paper we used the geographical definition of the Chihuahuan Desert from the Monterrey WWF workshop. We superimposed the GIS layers which provided the ecological boundary of the desert on political maps of the region in order to identify those municipios and counties that are, for the most part included in the Chihuahuan Desert region. We were then able to use recent census data to characterize land use and tenure in the Chihuahuan Desert. We wanted to use such local level data rather than state summaries because large parts of the states (such as Texas and Sonora) are not in the Chihuahuan Desert and because state level summaries hid tremendous geographical and social variations as more local levels. The counties and municipios included in the study are shown in Figures 1 and 2. The Chihuahuan Desert extends into all or part of three counties of southeastern Arizona, eight southern counties of New Mexico and 11 of the westernmost counties of the Trans Pecos Texas. In Texas, these counties are El Paso, Hudspeth, Brewster, Ward, Presidio, Terrell, Pecos, Reeves, Culberson, Jeff Davis, and Loving. In New Mexico, the counties are Hidalgo, Grant, Sierra, Luna, Eddy, Otero, Dona Ana, and part of Chavez. And in Arizona, the Chihuahuan Desert covers all of Cochise County, the southern part of Safford, and extends into Santa Cruz. According to the WWF map, it extends into Pima but where it does, the land is wilderness and range, and is considered by most to be part of the Sonoran/Chihuahuan transition zone. We have not, at this point, been able to link the GIS for US and Mexican portions of the Desert.

We selected several of the high priority terrestrial sites identified in the Monterrey workshop for more intensive analysis of land use and tenure as reported in the 1990 Mexican Agricultural Census. These include the Chiricahua/San Pedro area, the Mapimi, and Cuatro Cienegas regions. We also gained further insights into land use in major irrigation districts in the Chihuahuan Desert from a 1990 report of the Mexican irrigation districts.

The first section provides a brief history of land use and land tenure and the factors that have driven their transformation. The second section discusses the current patterns of land use and land tenure for the US and Mexican counties of the Chihuahuan Desert and for high priority conservation sites. The third section discusses the current legal economic. And political context for land use and land tenure in the region, and the paper concludes with a discussion of trends and projections to the future including, for example, the impacts of NAFTA, Mexico’s agrarian reforms, and new land use policies in the United States.
B. Historical Background

B.1. Land tenure and land use in the region during prehispanic and colonial periods

Until the Treaty of Guadalupe Hidalgo, for which 1998 makes the 150th anniversary, most of the Chihuahuan Desert shared a common history of Indian and colonial Spanish settlement. The physical geography of the region, especially the availability of water, has and continues to define settlement and land use patterns. Prior to the arrival of Europeans in the Americas, the peoples inhabiting the Chihuahuan Desert region consisted primarily of small bands of hunters and gatherers engaged in seasonal rounds, although some groups established permanent settlements where resources permitted. The collective term for these groups was “Chichimec”, although they spoke many different languages. The mesquite bush was an important basic food source. The indigenous peoples of the region established settlements along the Rio Grande and Pecos River Valleys in New Mexico and West Texas, and the San Pedro River valley in Arizona, where water was plentiful and agriculture could be supported. In Mexico, important archaeological sites such as Casas Grandes indicate the legacies of early occupancy of the Chihuahuan Desert. The San Pedro valley contains one of the most important archaeological sites where there is evidence of the so-called “Pleistocene overkill”- the hunting of megafauna by early peoples, perhaps to the level of extinction.

The Spanish were initially intimidated by the harsh environment and peoples of the Chihuahuan Desert, but the discovery of silver in Zacatecas in 1546 initiated a northward movement of Spanish settlers following the silver ores of the sierra Madre Occidental culminating in the famous mining settlement of Parral established in Chihuahua in 1631 (Figure 3). Another route of Spanish conquest followed the route of Coronado along the San Pedro River, and the establishment of missions in the Rio Sonora valley. The mines became the markets for a livestock industry that was established on the high grasslands of the Chihuahuan Desert. By the beginning of the 18th century ranchers and missionaries, supported militarily by Presidios, had crossed the Rio Grande into Texas, and stock raising and mining had become the main land uses of northern Mexico (West and Augelli, 1989).

The area continued to be sparsely inhabited in the early colonial period, nominally under the control of the Spanish crown. The dominant economic activity was mining, which generated a demand for food, tallow, hides, and other products produced with Indian labor on large estates in the region. The crown made some enormous land grants in northern Mexico. For example the marquis de Aguayo received an estate half the size of present day Coahuila. These estates were mainly used for raising cattle, but several also produced wheat and other crops for the mining and other settlements (figure 4). The Apache were one of several Indian groups who resisted Spanish domination and attacked settlements to obtain cattle and other resources.

By the end of the colonial period human activity had already altered the biodiversity of the Chihuahuan Desert. Impacts included possible over hunting of large mammals at the end of the ice age, the intentional and accidental use of fire in the grasslands, the domestication of maize and other crops, early irrigation systems, introduction of cattle and other exotics by the Spanish, and the destruction of forests for mining. European dominance also shifted attitudes to nature from a relationship based on use values and flexible or communal definitions of property to the view of resources as commodities to be bought and sold, and to private, often enclosed, property. The Catholic religion also rejected the animistic and pantheistic traditional beliefs of indigenous peoples that often resulted in a respectful rather than exploitative relation to nature.

B.2. Mexican Independence

When Mexico gained independence from Spain, the Mexican government continued to offer generous land grants to those willing to defend the area against Apache attacks. This created an alliance between peasants and hacendados (large landholders) at the same time that the peasantry was losing ground...
in the rest of the country (Katz 14). During this period, Mexican regions retained significant degrees of autonomy and policies other started at the state level. One such state program was the abolition of communal land ownership that transformed many Indian holdings into private property (Chihuahua 1825; Zacatecas 1825; Sinaloa and Sonora 1828). The national-level Ley Lerdo (1856) continued these policies, providing for the breakup of communal land holdings and the expropriated land holdings of the Church, although some regions provided for communal holdings to avoid the dangers of social instability that might arise from large numbers of indigenous landless. Although the stated intent behind these reforms was the creation of Jeffersonian yeoman farmers, the expropriated land was auctioned to the highest bidder and the most frequent result was extensive private estates, which contributed to the concentration of regional economic power in the hands of a few families. The land laws of 1875 and 1883 that permitted individuals to acquire vacant or untitled lands also reinforced the concentration of land holdings. Indigenous groups were often forced onto more marginal lands, into the Sierra, or became peon laborers on the large haciendas because they could not prove legal title.

The nineteenth century also saw massive land transfers from Mexico to the United States through a series of wars and treaties. When Texas won independence from Mexico in 1836 its territory included some of the Chihuahuan Desert. Most of New Mexico and northern Arizona was acquired from Mexico after the U.S. – Mexican War (1846-48) through the Treaty of Guadalupe Hidalgo. More territory, including Southern Arizona and Mesilla, was acquired in the 1953 Gadsden Purchase, in which the Land Grants established by Spanish and Mexican governments were to be respected.

The autonomy of the northern states of Mexico was reduced with the construction of railroads in the late 1800’s, although local politicians and families dominated at the state and regional levels. Mexican ores, often exploited with American capital, were shipped to the U.S. for smelting. In Chihuahua, the cattle industry boomed and at the national level commercial production for export replaced subsistence agriculture and small-scale farming. The introduction of irrigation in the Laguna region of Coahuila and Durango created a booming cotton industry; from 1880 to 1890 production quintupled, and it doubled in the following decade (MacLachian and Beezley 113).

Regional industries developed and the area became one of the country’s most important industrial zones, with increasing urbanization and a large number of immigrants from the U.S. as well as other regions of Mexico, attracted by the highest agricultural wages in the country (Katz 44). The rapid expansion of production in the north contributed to rapid rates of in-migration; by non-natives (MacLachlan and Beezley 1999:125). The region’s economy was relatively diversified, producing minerals and agricultural and timber products for exports, as well as goods for the local market (Katz 34). Economic and political power generally remained in the hands of families who dominated their states: the Terrazas-Creel in Chihuahua, the Maderos in Coahuila, and a handful of industrialists in Monterrey (Katz 43). By the turn of the century, the north could be considered the most modern region of the country, with a relatively urban population, diversified economy, and high literacy rate.

The shift to commercial export agriculture put pressure on domestic food supplies; by the 1870s protests, such as food riot in Durango involving 4000 people (Maclachlan and Beezley 189), started to break out. From the 1890s onwards. Mexico continually imported staple foodstuffs and the concentration of land eliminated the possibility of subsistence agriculture providing any sort of safety net. Nevertheless, the privatization of municipal and communal lands continued, allowing both foreigners and Mexicans to acquire and expand large landholdings. In 1907, a recession in the U.S. dragged the Mexican economy into a downturn with falling wages and mass layoffs, exacerbated by the return of migrant workers fro the U.S. and a coincident agricultural crisis precipitated by floods and droughts (Katz 64). This crisis hit particularly hard in the north, contributing to a united opposition to the national government. The hacendados of the region did not have a dispossessed peasant class to fear, they had claimed uninhabited lands and many developed a paternalistic relationship with their peons who received relatively high wages and degrees of freedom (72).

Porfirio Diaz was president of Mexico from 1877 to 1911, and under his dictatorship and encouragement of foreign investment the economy grew rapidly.
Widespread discontent with foreign control, the concentration of land into large private properties, and the impoverishment of the masses led to unrest, support for opposition leader Francisco Madero, and the Mexican Revolution.

B.3. The Mexican Revolution

From 1910 to 1917 the Mexican Revolution raged across northern Mexico, with leaders such as Zapata, Villa, Carranza and Madero competing for power. The Revolution devastated the countryside as rural people abandoned their crops, government support disappeared, and economic instability increased. Despite the election of Carranza as president in 1917, and establishment of a new constitution, it was not until the mid-1920s that partial stability returned to Mexico and the new constitution was fully implemented.

The Revolutionary constitution had great significance for land use and land tenure in northern Mexico. It included the rejection of foreign ownership of land and resources such as copper and oil, the restitution of land to indigenous peoples, the redistribution of land in the form of communal ejidos, and the expropriation of church property. The breakup of the large haciendas had no single result for ecosystems. In some cases, the ejidos chose to place more cattle or to convert grassland to crops, in others land use intensity declined because of lack of technical expertise or credit.

The full implementation of land reform began with the presidency of Lazaro Cardenas in 1934 who also nationalized the railroads and oil. During his presidency vast areas of productivity of state owned industry resulted in some expansion of resource extraction.

B.4. The Green Revolution

The 1950s brought several important changes of relevance to land use and land tenure in the Chihuahuan desert. In 1952, labor migration from Mexico to the United States was formalized through the Bracero guest farm worker program, resulting in millions of Mexicans traveling to work on US farms over the next two decades. This alternative employment opportunity resulted in the abandonment of some of the more marginal lands. This trend was exacerbated by the onset of the 1950s drought. This drought, the most severe on record in Chihuahua, resulted in widespread losses of crops and livestock as well as long term damage to natural ecosystems. The Palmer Drought Severity Index show values below –2 for this period indicating extreme drought conditions.

However, the Bracero program resulted in some investments in agriculture in Mexico as workers sent remittances back to their families. It has been estimated that these remittances now provide more than 50% of local income and investment in many rural communities.

At the same time, however, the Mexican government, with international assistance from the Rockefeller Foundation, initiated a new agricultural development program to increase yields of wheat and maize through the use of improved seeds, irrigation districts of northern Mexico, where government programs distributed improved wheat varieties and fertilizer. In many cases, yields increased dramatically, and Mexican wheat production soared.


Others are far more critical, suggesting that unequal access to irrigated land, credit and technology resulted in only a few regions and people reaping the benefits, and that the new inputs of seeds, water, and chemicals damaged ecosystems through loss of diversity, salinization, and pollution (Wright, 1991).

Since 1960 yields of basic crops have increased significantly in the states of the Chihuahuan Desert. Wheat acreage increased as a result of the Green Revolution, but was followed by a shift from basic grains to forage and vegetable production. Sorghum and alfalfa production has been increasing since the 1960s.
together with an increase in oilseeds in some irrigation districts. Overall crop acreage increased with the development of major irrigation districts.

The agricultural intensification of parts of the Chihuahuan Desert has affected several important ecosystems. For example, the expansion of irrigation in the La Laguna area, and the use of agricultural chemicals has reduced and put at risk areas of importance to migratory birds and amphibians.

**B.5. Mining and other industrial developments in Mexican Chihuahuan Desert**

Metal production in Northern Mexico grew considerably from 1920 to 1940, especially in Sonora and Chihuahua where gold production reached almost 10,000 kg by 1940, 350,000 kg of silver, 9,500 tons of copper, and 1.2 million tons of iron.

Sonora produced 100 kg of gold, 236.00 kg of silver, and 153,000 tons of copper by 1980, and Coahuilan silver production had grown to almost 60,000 kg. With iron production of 250,000 tons (Irey, 1990) (Figure 8).

**B.6. U.S. Settlement of the Chihuahuan Desert**

Similar patterns of land use based on mining and cattle are found in the US portion of the Chihuahuan Desert. Anglo settlement of the U.S. portion of the Chihuahuan Desert occurred mainly after the U.S. Civil War. The war brought many Anglo soldiers to the southwest U.S. for the first time, and many returned with their families to homestead the rich river valleys and graze livestock on the extensive grasslands after the war. The Homestead Act of 1862 gave settlers 160 acres, but allotments were later expanded to 640 acres by the Desert Land Act of 1875 (later reduced again to 320 acres) to allow for livestock grazing, which at the time was necessary for survival. Ineffective regulation of grazing let to and continues to degrade the ranges in all states.

After the Civil War cotton emerged as the major crop in the region. It was found to be resistant to harsh conditions, adaptable to phosphate-poor soils and saline water, valuable in the expanding reconstruction economy, and less damaging to the soil. Specialized cash-crop farming became the norm. And many of the new homesteaders were mid-westerners who imported their crops, like wheat, barley, corn, beans, and hay, and their farming techniques to the more delicate lands of the Chihuahuan Desert, leading to devastating effects in the 1930’s when inappropriate use of the land led to the Dustbowl.

Cotton also allowed for growth of spin-off industries as technology became available to further refine the cottonseed into value-added products like oil and textiles. Cotton also changed the labor and tenancy relations. An increasing number of sharecropping and tenant farmers let to an increasing number of people whose livelihood relied on agricultural production in the Chihuahuan Desert with fewer and fewer people owning the land and the means of production. As important as cotton became, the extensive use of the range for cattle grazing characterized all parts of the Chihuahuan Desert. In 1878, barbed wire made its appearance on the range, and cattle could for the first time be controlled on individual land holdings. This led to the need to legally define boundaries in the Desert.

The railroad (1891) spurred growth in the area of not only the urban areas of Las Cruces, El Paso, and Albuquerque, but also expanded commercial agricultural in the area as it allowed larger quantities of agricultural products to reach expanding markets in all parts of the U.S. Cattle ranching experienced a huge boom in the 1880’s – 1890’s as did corn and cotton operations. While cattle never exceeded corn and cotton in value during this time, it dominated the use of the majority of the land. Agricultural expansion was always, and remains, limited by the availability of water.

Mining, mainly of copper, also became a predominant use of land in the Chihuahuan Desert. The mines made their mark on the land by the open pits (which came in the 1940s), the huge tailings, slag and waste dumps, and especially by the denuding and deforestation of surrounding areas.

It was in the early part of this century that the different states took different paths to development. This was largely due to technology and resources, but also culture. In 1900 homesteading was ended and
Turner declared the closing of the American frontier. Arizona and New Mexico were still isolated from much of the US economy and the federal government held the majority of the land. In contrast, 98% of Texas land was in private hands by 1895. Industrial development in Texas was spurred by the 1901 discovery of vast oil reserves at Spindletop. The 1902 Reclamation Act brought ushered the construction of irrigation and flood control projects throughout the three U.S. states that include the Chihuahuan Desert, especially in New Mexico and Texas, along the Rio Grande and Pecos Rivers. Ground water was also tapped for the first time on an industrial scale by both privately funded and federal programs. Agriculture expanded and contracted in boom and bust cycles in relation to the discovery and depletion of new sources of water. The huge Elephant Butte Dam completed in eastern New Mexico in 1915, for example, spurred agricultural and urban growth. Other water projects such as the Avalon and McMillan dams in the Roswell and Carlsbad areas of New Mexico allowed for rapid expansion of agricultural and urban land use in those areas. The farming practices and crops brought to the Chihuahuan Desert by mid westerners, the expansion of the railroad, a plethora of new irrigation projects, and half-century of over grazing. Finally took its toll on the land. A worldwide depression and drought in the U. S. followed the last good farming season in 1929. Economic conditions both crushed demand and availability of credit to keep farming. Farmers were left with huge surpluses and the “Dust Bowl” of the mid 1930’s stripped the fields of the topsoil.

The government forced many farmers in West Texas and Eastern, New Mexico to retire their lands and sell the land to the land bank or BLM, or restricted them from using their lands under the Taylor Grazing Act of 1934 and the Soil Conservation Act of 1935. Many of those families still farming in Southeastern Arizona and Southwestern New Mexico are the same families who moved as a result of the Dust Bowl under the Resettlement Administration and Farm Security Administration. Throughout the twentieth century the US federal government retained most of the Arizona and New Mexico portions of the Chihuahuan Desert and the area along the Rio Grand through Big Bend in public lands. Because both the Forest Service and the BLM focused on using the lands forest and grasslands were heavily used for livestock grazing and logging. Only the parks remained relatively unused although tourist pressures increased with more leisure time in the 1950s.

C. Recent and current patterns of land use and land tenure

C.1 Changes in Mexican land use and land tenure in last 25 years.

A brief analysis of state level data suggests how land use and tenure in the Mexican Chihuahuan Desert has changed in the last few decades. Since the 1970 agricultural census, the area of cropland and pasture has increased, and forest cover has decreased. There have been significant changes in the crop mix, associated with changes in world markets and government subsidies. In the states of Chihuahua and Coahuila, the area in crops for human consumption has decreased by about 10%, whereas the area in forage, particularly oats and alfalfa, has increased. Cotton acreage and wheat for export have declined. In Sonora, the crop shift was from basic grains and beans into oilseeds, forage, and vegetables (Lorey, 1993)

These changes are consistent with those described by Sanderson (1986) who analyzes the growth of the fruit and vegetable and livestock sectors. Nevertheless, large areas have been maintained in wheat, maize and beans as a result of government subsidies, tradition, and lack access to water or credit for alternative crops.

Redistribution of land slowed in the last couple of decades, with few new ejidos established in the Mexican north. Land concentration increased, often through the illegal renting of ejido lands, especially grazing land and irrigated area, to larger landholders.

C.2. Current land tenure in the Mexican Chihuahuan Desert
The basis for analysis of land tenure in the overall Chihuahuan Desert is the 1990 Mexican Agricultural census that reports land holding sizes and tenure for each municipio (INEGI, 1995). The 1990 census is considered relatively reliable and reports a wide range of variables for several landholding sizes and tenures at the municipio level.

For those municipios within the Chihuahuan Desert the 1990 census reports an average percentage of land in private tenure at about 65%, higher than the Mexico wide average of 52%. In three-quarters of the municipios, more than half of all arable land is privately owned. Ejido land is concentrated in the states of Zacatecas, San Luis Potosi, and Durango, where more than 40 percent of all land is ejidal over much of the region (Figure 9). Land is more heavily concentrated in private hands as one moves north within Mexico, particularly within the northeastern area of the bioregion. The percentage of land in private land ownership ranges from approximately 10 percent in Praxedes de Guerrero, Chihuahua to 98.8 percent in Coronado, Chihuahua. State averages for private land ownership range from 54 percent in Durango and San Luis Potosi to a high of 84.9 percent in Chihuahua (Table 1).

In the border areas, land is primarily held in private ownership, where there is a higher percentage of ejido tenure in the southern states of the region. High percentages of ejido ownership are found around the Mapimi, Cuatro Cienegas, and Cuenca del Rio Nazas regions. “Mixed”? ejido and private ownership accounts for less than six percent of all productive land in the Chihuahuan Desert region of every state but Zacatecas (10.9%) and Durango (9.4%).

<table>
<thead>
<tr>
<th>Municipio</th>
<th>Private ownership ranges from lowest to highest municipio within the state</th>
<th>Average for municipios within the state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chihuahua</td>
<td>9.1 to 98.8%</td>
<td>84.9</td>
</tr>
<tr>
<td>Sonora</td>
<td>44.3 to 94.6%</td>
<td>76.8</td>
</tr>
<tr>
<td>Coahuila</td>
<td>14.5 to 98.5%</td>
<td>73.9</td>
</tr>
<tr>
<td>Nuevo Leon</td>
<td>46.8 to 94.6%</td>
<td>69.4</td>
</tr>
<tr>
<td>Zacatecas</td>
<td>19.3 to 91%</td>
<td>59.3</td>
</tr>
<tr>
<td>Durango</td>
<td>23.7 to 93%</td>
<td>54.7</td>
</tr>
<tr>
<td>San Luis Potosi</td>
<td>11.8 to 78.2%</td>
<td>54.6</td>
</tr>
</tbody>
</table>

The pattern of land size distribution reflects, to some extent, that of land tenure. Larger landholdings are more predominant in the north (Figure 9), reflecting larger landholdings in private hands than in ejidos. For the Chihuahuan Desert regions of Coahuila (58.75%), Chihuahua (60.25%), and Sonora (85.52%), more than half of all arable land is held in tracts of at least 2500 hectares.

Very little land is in small plots, traditionally defined as less than 5 hectares. No municipio has more than 50% of all arable land in small plots, and many have less than five percent of arable land held in plots of less than five hectares. Those that do have more small landholdings tend to be in the southern portion of the bioregion, particularly near the priority areas of Mapimi, Cuatro Ciénegas, Cuenca del Rio Nazas, the Altiplano Mexicano Nororiental, and Huizache-Cerritos (Figure 11).

The large landholdings in the north overlap with the region in which pasture is the most dominant form of land use: there is an almost perfect one-to-one correlation between municipios with a large percent of land in pasture and the majority of plots of over 100 hectares.

The implications of land tenure and landholding size for conservation are by no means clear in either the United States or Mexico. Although some authors have claimed that ejido land tends to be inefficiently used or overgrazed (Dovring, 1970; Mueller, 1970) others suggest that many ejidos are productive and relatively benign in their environmental impacts because of low use of chemical inputs or lack of capital for
livestock (Tuckman, 1976; Nguyen, 1979. Whilst some large landowners leave their property relatively
underdeveloped and wild, others employ intensive agricultural technologies or exceed the carrying capacity
of the range.

C.3. Current land cover in Mexico

The 1990 INEGI census includes 24,429,582.25 hectares of land within the Chihuahuan Desert. Of
this area, 10% is reported as cropland, 88% as open pasture, and less than 2% as forest (Figure 12). It
should be noted that the agricultural census does not inventory the complete area of all Mexican states. The
seven states if the Chihuahuan Desert can grouped roughly into three regions: the north, consisting of
Sonora, Chihuahua, and Coahuila; the central desert, comprising Durango and Nuevo Leon; and the south
consisting of Zacatecas and San Luis Potosi. Land use trends are relatively consistent across regions, but
vary between them.

The greats percentages of cropland are in the south (Figure 13), while pasturelands cover much of
the northern two-thirds of the desert (Figure 14). The most heavily forested lands are in the south and along
the eastern and western edges of the desert (Figure 15).

In the northern states, the crop area is less than 6% of the total area (5.08% in Chihuahua, 5.83% in
Coahuila, and 2.18% in Sonora). In the central region, the percentage of cropland increases to
approximately 20% (19.86% in Durango, 22.75% in Nuevo Leon). The greatest percentages of cropland are
in the south, where it is over 30% of the total land area (30.89% in Zacatecas, 36.34% in San Luis Potosi).
In some municipios in the south, over 90% of the land area is suitable for crops (Figure 13). Temperature
and water availability are more favorable in the south than in the north, where crops would need to adapt to
extremes of temperature and would require extensive irrigation. Plots are also smaller and ejidal,
suggesting that more agriculture may be for home consumption in the south.

The opposite is true of the percentage of land in natural pasture, which is greatest in the north, where
it is well over 75% of the total land area (93.56% in Chihuahua, 92.74% in Coahuila, and 97.74% in
Sonora). Southwestern Chihuahua has slightly less than the state average in pasture, through pasture still
covers over 80%. In the central region, the area in natural pasture decreases to 70-75% (70.35% in Durango, 75.58% in Nuevo Leon), and in the south, it is less than 70% (68.55% in Zacatecas, 62.23% in
San Luis Potosi). In general, the northern portions of these states have higher percentages of land in pasture
than the south. Again, this is consistent with temperature and water availability as well as land tenure
(Figure 14).

The total area with forest (including mixed forest and pasture) is less than 1% in most of the north
and the south (0.83% Chihuahua, 0.50% in Coahuila, 0.04% in Sonora, 0.24% in Zacatecas, and 0.33% in
San Luis Potosi). In the central region, Durango has forest on 8.85% of its desert lands, while 1.44% of the
desert lands of Nuevo Leon contain forest (Figure 15).

C.4. Crop production in Mexican Chihuahuan Desert

Of the general land use category of cropland, about 60% was reported as actually sown with crops in
the 1990-91 period. Of the total area sown throughout the year, almost 90% grows annual crops, and 15%
perennials. The total area actually sown with crops is greatest in the southern region, where it is over 68%
of the arable area (78.74% in Zacatecas 68.57% in San Luis Potosi). Within these states, cropped land is
greatest in the western municipios. In the central region, it decreases to about 55-60% (60.85% in Durango,
54.23% in Nuevo Leon), through the percentage of land that is cropped varies greatly between municipios,
from less than 40% to over 78%. In the northern region (excluding Sonora), cropped land is 45-50% of the
total arable area (50.09% in Chihuahua, 45.74% in Coahuila). Again, the state average does not show the

\[1 \text{ The southern part of Coahuila is more properly in the central region, but because calculations are at the state level, we have}
\text{placed all of Coahuila in the north.}\]
variance between municipios. Cropped land ranges from less than 40% to more than 78% of the arable area in this region. Sonora has the least cropped land, only 16.27% of the arable land, though the municipio of Naco has over 41% of its arable land in crops. Perennials are most prevalent in the irrigated areas of the northern two-thirds of the desert region. Twelve annual crops account for 88% of the total crops account for 88% of the total cropped area. During the spring-summer season, beans and maize comprise 42% and 34%, respectively of the total area sown.

Annual crops are particularly prevalent in the south, though no municipio in the desert bioregion has less than 17% of its cropped land sown with annuals. Throughout the Chihuahuan Desert, the spring-summer planting season is the most important. Beans and maize are the two major crops in all of the states, though beans are particularly important in the south and in Durango they are the main crop in both Zacatecas (70.73% of the total cropped area) and Durango (54.41%). In Durango they are grown primarily in the southern municipios In Zacatecas and in San Luis Potosi, where they are the second-most important crop (43.32%), beans are grown particularly in the southwestern municipios. Beans are also the second most important crop in Nuevo Leon (15.69%), and Coahuila (13.66%). In Sonora, beans are the main crop, though they are planted on only 14.48% of the land. They are also an important crop in Chihuahua (11.52% of the total cropped). However, in the municipios of Chihuahua and Aquiles Serdán, beans are planted on over 44% of the cropped area, raising the state average. During the winter season, beans are grown throughout the Chihuahuan Desert, but in small amounts (less than 1%). Winter production is primarily in the eastern half of the desert, as well as in the municipios of Agua Prieta and Bavispe in Sonora, and Janos in Chihuahua.

Maiz is the primary crop in the eastern states of Nuevo Leon (68.77% of the total cropped area), where it is grown primarily in the southern municipios (Galeana, Doctor Arroyo, and Mier Y Noriega); and San Luis Potosi (68.51%), as well as the northern states of Chihuahua (28.09%), especially in the municipios of Rosario, Satevó, and Valle de Zaragoza; and in Coahuila (30.67%) (Figure 16). In the other three states, maize is the second most important crop. It is grown on over 20% of the land in Durango (24.14%) and Zacatecas (21.10%), as well as on 11.75% of the cropped land in Sonora. In the winter, maize is important primarily in San Luis Potosi (4.20%), though it is also grown in Nuevo Leon, Sonora, and Coahuila.

Cotton is grown almost exclusively in the north (Figure 17). It accounts for just over 12% of the total cropped area in both Coahuila (12.29%) and Chihuahua (12.42%), and 7.04% in Sonora. It is also grown in Durango (1.99%). In the winter cotton is grown in negligible amounts in Coahuila and Durango. Cotton production is significant for conservation because of the large amounts of pesticides that tend to be used on this commercial crop.

Also important in the north is sorghum, which is planted on 7.63% of the cropped land in Sonora, 6.81% in Chihuahua, and 4.72% in Coahuila. Sorghum is also planted in the central states of Durango (2.53% and Nuevo Leon (1.97%). It is grown in small amounts (less than 1% in the same regions during the winter and is mainly used for animal feed.

Oats are grown throughout the Chihuahuan Desert, particularly in the southwestern region (4.04% in Zacatecas, 2.70% in Durango) and in the north (2.06% in Sonora, 1.44% in Chihuahua and 1.28% in Coahuila). Most of the production occurs along the eastern and western edges of the desert. During the winter season, oats are an important crop in Sonora (10.70%) and Coahuila (3.20%) and are grown in smaller amounts in the other states. They are also primarily for animal feed.

Soybeans are grown only in summer and almost exclusively in Chihuahua (2.92%). Barley is planted in the central region (2.71% in Durango, 2.02 % in Nuevo Leon), particularly in the east and west; and in Sonora (1.45%). In the winter, barley becomes more important in Sonora (3.98% of the total area cropped throughout the year) and is grown in smaller amounts throughout the rest of the desert region, particularly the north.

In the summer, wheat is planted in the central region (1.86% in Durango, 1.26% in Nuevo Leon) and in Chihuahua (1.66%). However, wheat is a more important crop during the winter season (Figure 18). It is
grown primarily in the north (11.81% in Chihuahua, 3.9y% in Coahuila, 3.06% in Sonora) and the central region (1.92% in Nuevo Leon, 1.8% in Durango).

Other annual crops (safflower, sesame, rice, and chickpeas) are grown in very small amounts in the region. Of these, safflower is grown almost exclusively in the central region, and chickpeas in the south. Sesame is grown in scattered municipios in Coahuila and Nuevo Leon. Only safflower is grown in larger amounts during the winter season, though the area devoted to this crop remains less than 1% in the four states (Durango, Coahuila, Chihuahua and San Luis Potosi) that plant it. Of these states Chihuahua and Coahuila are the most important winter safflower producers.

Perennial crops are particularly important in the northern region, especially Sonora. Alfalfa is planted on 22.50% of the total cropped area in Sonora, 11.53% of the cropped land in Chihuahua, and 7.03% of the cropped land in Coahuila. In all three of these states, the portion of cropped land planted with alfalfa ranges from 1% in some municipios to over 50% in others (figure 19). Alfalfa is also grown on 3.88% of the cropped land in Durango. Alfalfa production contributes to the growing importance of livestock in northern Mexico, and is environmentally significant because of its heavy water requirements.

Planted pasture grasses such as buffel are also important in the north. They are planted on 26.48% of the cropped land in Sonora, 4.37% of the cropped land in Chihuahua, and 8.56% of the cropped land in Coahuila. Grasses also grow on 8.30% of the cropped land in Nuevo Leon.

The other major perennial crops (coffee, sugar cane, century plant or agave, oranges and bananas) are planted on smaller areas in scattered municipios throughout the desert region. Agave is important primarily in the southern half of the desert, particularly in the eastern municipios. Oranges are grown primarily in the south-central region, and sugarcane in the north and north-central part of the desert. Bananas grown in clusters of municipios throughout Chihuahuan Desert region.

A correlation analysis suggest that ejido tenure is associated with a higher percentage of land in beans and maize, and that larger landholdings tend to produce cash rather than subsistence crops.

The census also provides information on the irrigation of cropland in the Chihuahuan Desert municipios. Irrigation from surface water occurs on about 40% of the production units in the region, mostly on those under 100 hectares in size. Irrigation from ground water wells occurs on about 20% of production units, mainly those from 5 to 100 hectares in size. Municipios with over 20% of the land irrigated from surface water sources are clustered in the central regions of the Chihuahuan Desert, primarily along the Rio Conchos (Figure 20). The total irrigated area is more than 1000 hectares per municipio in the region around Torreón (where the Laguna project is located) and south of Chihuahua along the Rio Conchos (Figure 21). Groundwater is used on over 20% of the crop area in the north central region, and relatively little ground or surface irrigation is found in the southern and western margins of the region, except along the border with the US (Figure 22). Large areas irrigated by groundwater are found in the municipios of Hidalgo del Parral and Saltillo, in La Laguna near the city of Torreón, and north of the city of Zacatecas (Figure 23). Of the crop area irrigated by surface water, a considerable percent of the area is in ejido tenure; ejidos also receive a significant proportion of the groundwater for irrigation, especially in the area south of Ciudad Juarez along the Rio Grande (Figures 24 and 25).


Arizona, New Mexico and Texas have had their own history of land tenure, but settlement and use patterns, U.S. agricultural policy, and the technological changes affecting land use have all affected them in much the same way, making some generalizations possible.

All non-grazing agricultural activity in all three states has and continues to be limited by the availability and cost of water. Discoveries of new ground water sources, the construction of flood control and irrigation projects such as the Elephant Butte Dam, and the Avalon and McMillan reservoirs near Roswell and Carlsbad, New Mexico, have determined expansion of agricultural land uses to a greater extent than changes in the market. This continues to be the case except in the areas closest to the Rio Grande and Pecos Rivers. In areas where irrigation water is scarce and expensive, and where expansion has been
restricted by policy, farmers have turned away from cotton, corn sorghum, alfalfa and grains – the traditionally dominant crops – to more valuable crops that provide better returns to capital investment such as walnuts or vegetables.

The Douglas Irrigation District in Cochise and Santa Cruz counties of Arizona is a good example. Recent legislation (1980) designated the district a non-expansion area for use of groundwater. Those farmers with access to capital have responded by diversifying their operations into year-round vegetables in greenhouses and into the expansion of peach and apple orchards. Wheat, sorghum, and cotton remain important.

Over the last 30 years or so, contrary to what might be suspected, farm size decreased almost across the board and the number of farms increased in almost every case. Even in the rapidly urbanizing county of El Paso, the number of farms only decreased 3%. In urbanizing Dona Ana, which includes the Las Cruces-El Paso urban area, farm acreage grew 31%, and the number of farms increased 35%. This trend partly reflects an increasing number of hobby farmers and new irrigation units in the region (Figure 26).

**C.7. Land cover in the US Chihuahuan Desert**

Historically, and currently, the predominant use of land in the US region of the Chihuahuan Desert is livestock grazing, much of it on land owned by the Bureau of land Management. An indication of overall land uses can be seen in the case of New Mexico (Figure 27) where most of the land is used for grazing, but urban, cropland and parks have increased in the last 50 years. Overall the Federal government controls more than 80% of the US Chihuahuan Desert including tribal and defense lands, as well as resource land managed by the Forest Service, Bureau of Land Management, Fish and Wildlife Service, and National parks Service (Figure 28).

Federal lands held by BLM, some of the lands held by the military, and most state lands, are managed under a multiple-use strategy, allowing private leases for grazing and mining. The majority of military land remains wild. About 13% of BLM lands in southern New Mexico are designated Wilderness Study Areas and are totally protected from development.

In New Mexico, while the military use of land limits development of the Chihuahuan Desert, it is the main factor in the development of many of the urban areas of the region, particularly the towns of Roswell and Alamogordo, NM. Both private and NASA military missile and other aerospace testing continue to be an important use of land in Southern New Mexico. The White Sands Missile Range – 100 miles north to south by 40 miles east to west, almost 3,200 square miles – is the largest military installation in the country. Adjacent to this, one of the largest new industrial developments in the state is being planned. The New Mexico Space port is intended as a complementary test site to be developed and used by private aerospace industry and will contribute to the adjacent urban areas.

**C.8. Land Tenure**

The regions of Arizona, New Mexico, and Texas included in the Chihuahuan Desert have very different regimes of land tenure/ownership, but are very similar in land use.

While 45% of land in Arizona is federally owned, the counties included in the Chihuahuan Desert differ from the rest of the state. In the southeastern counties of Arizona – southern Greenlee and Graham counties, all of Cochise and Santa Cruz counties – the land is mostly controlled by the state or is privately owned ranch land. The privately owned land is owned by families or Arizona companies, rather than part of larger national agribusiness operations.

Besides the National Forest lands and BLM holdings in southeastern Arizona, the US Army’s Fort Huachuca not only contributes greatly to urban development in nearby Sierra Visa, but is a threat to the San Pedro River and surrounding areas (see Protected Areas in Arizona).
Table 2: Arizona land Tenure

<table>
<thead>
<tr>
<th>County</th>
<th>% Forest Service</th>
<th>% BLM</th>
<th>% State</th>
<th>% Indian</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochise</td>
<td>12</td>
<td>7</td>
<td>35</td>
<td>NA</td>
<td>43</td>
</tr>
<tr>
<td>Graham</td>
<td>13</td>
<td>26</td>
<td>18</td>
<td>37</td>
<td>6</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>53</td>
<td>NA</td>
<td>8</td>
<td>NA</td>
<td>39</td>
</tr>
</tbody>
</table>

The largest federal landholding in Santa Cruz County are part of the Coronado National Forest, probably not considered in the Chihuahuan Desert study area. The large Bureau of Indian Affairs land holdings in Graham County belong to the San Carlos Apache Reservation and are also to be excluded from study area.

Table 3: New Mexico land tenure

<table>
<thead>
<tr>
<th>County</th>
<th>% Federal</th>
<th>% State</th>
<th>% Indian</th>
<th>% Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chavez</td>
<td>32.4</td>
<td>18.0</td>
<td>Na</td>
<td>49.5</td>
</tr>
<tr>
<td>Doña Ana</td>
<td>74.8</td>
<td>11.8</td>
<td>Na</td>
<td>13.4</td>
</tr>
<tr>
<td>Hidalgo</td>
<td>40.5</td>
<td>16.1</td>
<td>Na</td>
<td>43.4</td>
</tr>
<tr>
<td>Grant</td>
<td>51.0</td>
<td>14.5</td>
<td>Na</td>
<td>34.6</td>
</tr>
<tr>
<td>Sierra</td>
<td>67.8</td>
<td>13.4</td>
<td>Na</td>
<td>18.8</td>
</tr>
<tr>
<td>Otero</td>
<td>68.8</td>
<td>10.6</td>
<td>10.8</td>
<td>10.6</td>
</tr>
<tr>
<td>Eddy</td>
<td>61.6</td>
<td>17.9</td>
<td>Na</td>
<td>205</td>
</tr>
<tr>
<td>Luna</td>
<td>41.5</td>
<td>28.3</td>
<td>Na</td>
<td>30.2</td>
</tr>
</tbody>
</table>

In contrast to Arizona, the majority of land in the Chihuahuan Desert counties of New Mexico is federally owned. Much of this land is managed by the BLM, the Army and the Air Force, and is largely wilderness. Holloman Air Force Base, White Sands Missile Range, and White Sands National Park account for the majority of non BLM lands. The rest – in the millions of acres – is managed by BLM and is divided into areas with varying degrees of protection.

In Texas, only 2% of the entire state is federally owned land. The most important of this federally managed land in the Upper Rio Grande or Trans Pecos Texas is the Fort Bliss military base near El Paso, and Big Bend National Park. The rest of the land is state owned and privately owned, with the majority managed by the Texas General land Office. (see Protected Areas in Texas). We could not find a reliable source that divided Texas land according to state, federal, private, and Indian. This would probably not be valuable as public holdings represent such a small percent of overall total.

C.9. Land Use in the United States Chihuahuan Desert

In New Mexico, the Rincon and Mesilla Valleys of New Mexico are the most important Agricultural areas of the state. Here, the expansion of more valuable crops such as chilies, onions, lettuce and tomatoes has put the region in a position to directly compete with winter vegetables from Mexico.

Cotton, grains, and feed crops remain important, especially in southeastern New Mexico and West Texas areas (Figure 29). El Paso County for instance, has not significantly decreased irrigated acres of farmland devoted to alfalfa and cotton despite its growing urban area. West Texas remains almost exclusively rangeland, with the exception of Terrell County, which increased irrigated cropland 363% between 1982 and 1992.

Cotton production has decreased in almost all areas where subsidized water sources are scarce or nonexistent (Figure 30). These are Cochise, AZ, and southwestern New Mexico counties, Hidalgo, Luna and Sierra. All of these counties have decreased cotton production by over 65%. Alfalfa for hay has also decreased in 15 of 19 counties for which such information was available.
Acreage of irrigated cropland has decreased in some areas and increased in others, making it hard to generalize. Acreage doubled in Santa Cruz, AZ, and Ward and Terrell, TX, while it decreased dramatically in Presidio, Culberson, TX, and Grant and Hidalgo of southwestern New Mexico.

A marked trend can be seen in the increase of vegetable production. In all states where vegetables can be commercially produced, farming has intensified and increased dramatically. Otero and Eddy counties, in New Mexico, increased vegetable production 1116% and 622% respectively. In neighboring Hidalgo (215%), Graham (291%) and Cochise (63%) counties farming increased as well. This is associated with increases in year-round production, mostly of chilies, onions, tomatoes, and lettuce (Figure 31)/

Orchard acreage increased as well, especially in Sierra (536%), Graham (325%), Santa Cruz (195%), Eddy (183%), Luna (111%), and Doña Ana (41%). These are fruit and pecan orchards, both high value crops.

There is extensive use of fertilizer and pesticides across the region, especially in those areas where cotton or vegetables are grown (Figure 32 and 33). These agricultural chemicals can pose risks to biodiversity.

D. **Case Studies of Land Use and Land Tenure around high priority conservation sites and in irrigation districts.**

D.1. **Land Tenure and use around priority sites**

In the Chiricahua/San Pedro area most cropland is in private hands, particularly in the two Sonoran municipios where over ninety percent is held privately (91% in Agua Prieta and 94.5% in Bavispe). In the Chihuahuan municipio of Janos, on 64% is in private hands, with the bulk of the rest (35.6%) ejidos. In each of the three cases, most land is in holdings of more than 2500 hectares: 63.4% in Janos. 75.5% in Bavispe, and 81.5% in Agua Prieta. Less than one percent of land in each municipio is in what is traditionally considered to be “small” landholdings (less than five hectares). The WWF workshop identified this region as intact’, which appears consistent with the land use date that shows little cropland. Only a small part of the Mexican portion of the Chiricahua region is in agriculture (1.27% in the municipio of Agua Prieta, Sonora; 3.95% in Bavispe, Sonora; and 5.98% in Janos, Chihuahua). Crops are planted on less than half of the arable land. The vast majority of the land in this region is in natural pasture (98.57% in Agua Prieta, 96.03% in Bavispe, and 79.68% in Janos). Forest covers less than 1% in the two Sonoran municipios, while 14.13% of Janos is forested. The Sierra de Los Ajos are protected under Mexican Forestry law and are in development for a Biosphere reserve. In all three municipios, less than 0.25% is classified as unproductive. The possible expansion of the mine at Cananea could increase water use and the risks of pollution in the area. Other mine developments are planned between Cananea and Magdalena.

On the US side a considerable area is offered some protection from development by the US forest service in the Chiricahuas and the San Pedro riparian Conservation Area. However, the San Pedro valley is under heavy development pressure from the expansion of Fort Huachuca and the growth of retirement communities. This is placing particular pressure on groundwater resources that are linked to the flow of the San Pedro River.

The WWF considers this region a terrestrial and freshwater priority site and ranks the threat to the ecosystem from human activity from medium to high. The threats identified by the Monterrey workshop include extraction of groundwater for agriculture, water diversions for agriculture, housing developments, overgrazing, illegal hunting and collecting activities, recreation, timber harvesting, municipal water pollution and the impact of mining.

In three of the four municipios in the Mapimi area, private ownership predominates, ranging from 97.3% in Sierra Mojada and 84.4% in Jimenez to 71.4 in Mapimi. In Tlahualillo, however, ejidal holdings account for 72.1% of the worked area within the municipio. Over half the arable land in each municipio, however, is held in titles of more than 2500 hectares. This ranges from a low of 52.7T in Mapimi, to levels approaching 70% in each of the other three municipios (68.6T in Sierra Mojada, 70.1% in Tlahualillo, and
71.4% in Jimenez). Small plots (less than 5 hectares) account for no more than one percent of holding in any municipio. Arable land is relatively low at 5.43% in Jimenez, Chihuahua: 1.30% in Sierra Mojada, Coahuila; 12.49% in Mapimi, Durango, 12.43% in Tlahualillo. Of this land, the percentage in actual crops includes 51.02% of arable land in Jimenez, 13.41% in Sierra Mojada, 18.33% in Mapimi, and 51.07% in Tlahualillo.

Pasture is the main land use in these municipios at 94.34% in Jimenez, 97.81% in Sierra Mojada, 85.80% in Mapimi, 87.09% in Tlahualillo. The threats listed in Desert Conservation Workshop report include overgrazing of goats, sheep and pigs that compete with native herbivores for forage, illegal hunting, over collection of birds, cacti, and reptiles, timber harvesting, unsustainable harvesting of native plants, and groundwater pumping and water diversions for agriculture in southwestern portion of the area.

In the Cuatro Cienegas priority area ownership of land is mixed between ejidal and private holdings. In the municipios of Cuatro Cienegas and Sacramento, private ownership is by far the dominant form of ownership, accounting for 98.5% and 94.3% respectively. On the other hand, in san Pedro and Francisco I. Madero, ejidal land represents the bulk of the arable area, as in San Pedro ejidos control 79.2% of arable land and in Francisco I. Madero, 85.97% of all land is ejidal. Land distribution is similarly disparate, but odes not follow the same pattern. Holdings of more than 250 hectares are more prevalent in Cuatro Cienegas (92.8%) and San Pedro (90.1%), but somewhat less dominant in Francisco I. Madero (74.3%) and Sacramento (63%). However, as one might expect, small holding, although clearly relatively unimportant, are more heavily represented in the municipios where ejidos dominate. In Francisco I. Madero 9.4% of the worked land is in plots of less than five hectares; in San Pedro the figure is 13.1%. it is likely that these municipios will be affected by the agrarian reforms of the past few years, as ejidatarios take advantage of the property rights transferred to ejidos, but the large size of the holdings may allow the ejidos to withstand the changes in the marketplace. As in the San Pedro/Chiricahua, the vast majority of the land is in natural pasture (96.64% in the municipio of Cuatro Cienegas, 90.01% in Francisco I. Madero, 88.71% in Sacramento, and 84.15% in San Pedro). The arable land is only 3.16% of the total Cuatro Cienegas, 8.72% in Francisco I Madero, 11.20% in Sacramento, and 15.49% in San Pedro. Of this 29.96% is in crops in Cuatro Cienegas, 84.07% in Francisco I Madero, 41.51% in Sacramento, and 90.47% in San Pedro.

Forestland is minimal. The threats listed in the WWF Desert Conservation Workshop report include groundwater pumping for agricultural and municipal uses, water diversions from springs, channelization of streams feeding springs and wetlands. Gypsum mining, invasion of exotic species, illegal hunting, unsustainable harvesting of candelilla and cacti, and overgrazing by goats and horses.

### D.3. Land tenure and use in key irrigation districts

A. 1990 report from Mexican irrigation districts provides some details on land use and tenure in the major irrigation districts of the Chihuahuan Desert (Comision Nacional de Agua 1990). The irrigation districts are significant to conservation because they are major water users and often sources of pollution from fertilizers and pesticides. We examined the characteristics of several important irrigation districts in the Chihuahuan Desert for further information on land tenure and use. The districts are shown in Figure 34.

The Delicias Irrigation district on the Rio Conchos is 90.4% in active irrigation and about 50% ejido and private land tenure. Ejidos have about 60% of the plots between 5 and 10 hectares and 40% under 5 hectares. Of the private land 45% is under 5 hectares, 25% between 5 and 10 hectares, 30% between 10 and 20 hectares. The principal crops are wheat, alfalfa, cotton, peanuts and walnuts with secondary crops of chile, maize, soy, and sorghum. In the winter most of the land (86%) is in oats, while in summer land use is split between cotton (27%), peanuts (24%), chile (13%), and maize (12%). Alfalfa and walnuts are important perennial crops.

The Valle de Juarez irrigation district along the Rio Bravo/Grande is about 65% in active irrigation. Of the 60% of the land in ejidos, about 60% are between 5 and 10 hectares and 30% are under 5 hectares. Of the private land, about 50% is held in plots under 5 hectares, about 25% between 5 and 10, and 15% between 10 and 20 hectares. The principal crops are wheat, cotton fruit, and alfalfa, and almost all of the
land uses chemical fertilizers and hybrid seeds. There are more than 350 tractors. In fall and winter the annual crop area includes wheat (43% of the area) and oats (34%) and in summer almost 95% of annual area is in cotton. The perennial land is almost all in alfalfa. The district has almost 32,000 cattle and sell milk and wool.

The Bajo Rio Conchos district is about 60% in active irrigation. Ejidos are about 55% from 5 to 10 hectares and 30% under 5 hectares. Private lands are about 40% under 5 hectares, 25% between 5 and 10, and 25% over 10 hectares. The most important winter crop is wheat, and in summer about 60% of the annual production is cotton. Alfalfa is an important perennial crop.

The important Lagunera district is only 40% in active irrigation, mostly gravity fed, and has more than 2700 tractors. About 85% of all landowners use fertilizer, and more than 90% hybrid seeds. Important winter crops include oats (60%) and zacate grass (30%). In summer, cotton is the major annual (65%). The perennial crops include alfalfa and walnuts. The district reports more than 200,000 goats, 45,000 pigs and almost 100,000 cattle.

E. Social driving forces for land use and land tenure changes

The land tenure and use patterns and trends described above are a result of a variety of factors including physical geography (climate, soils, topography, hydrology, mineral endowment), prices and markets, and government policies, especially those concerning agriculture.

E.1. US Agriculture Policy

Since the 1930s farming has come and gone in the US southwest in boom and bust cycles related to water availability, technology and changing markets. New fertilizers and chemical inputs, as well as new more resilient crops in the 1960s let to intensification and expansion of crops such as sorghum and alfalfa. The post Depression era is characterized by larger more capital intensive agricultural operations. Agricultural policy shifts emphasizing export markets let farmers to seek competitive advantages over other regions of the country producing the same crops.

The 1970s began a trend in which farmers began to grow more vegetables and fruits, whose return is much greater than grains and cotton, but whose capital outlay is more intensive. This is particularly true in areas where federally subsidized water is not available or is expensive, such as southeastern Arizona and southwestern New Mexico. In Cochise County, Arizona, for example orchards and greenhouses have expanded, as well as pivot irrigation systems.

The 1973 Agriculture and Consumer Protection Act, which has since been amended and strengthened, set the standard that farm subsidies would never rise above market levels. The 1996 Farm Bill, for example, provides support for basic grains until 2002, while encouraging farmers to plant “for the market”. Guarantees remain tied to market prices. Agriculture is no longer insulated from the market, and this fact has dictated many of the changes seen over the last 10-15 years.

Since the late 1970s, trade and agricultural policies have encouraged the expansion of agriculture for export markets. However, the strong U.S. dollar, the international debt and inflationary crises of the 1980’s, and the expanding financial crisis and currency devaluations in almost every international market which imports U.S. agriculture, have made this difficult.

The North American Free Trade Agreement has opened up the U.S. market to Mexico’s agricultural products. Many of the same crops such as vegetables that are grown more expensively in the Southwest . The devalued peso, cheap labor, and strong dollar make Mexico’s products more competitive. Also the 1986Immigration Act restricting immigration, as well as the current crackdown on undocumented aliens by the Immigration Service, make labor in the U.S. much more scare and expensive. Recent and pending legislation regarding quality and health standard for Mexican products will increase the costs of production in Mexico and make products more expensive and possibly encourage U.S. farmers in the Southwest to gain
advantage. These developments may have the impact of increasing the intensity of agriculture as well as
determining the mix of crops. In favor of the more valuable crops where there is a comparative advantage.

E.2. Debates over land use in the US Chihuahuan Desert

Although land use in the US Chihuahuan Desert has remained fairly stable in recent years, there are
important pressures driving changes in specific places and that may influence future patterns. These
includes shifts in Federal defense spending that have resulted in the reductions in use of some military lands
and intensification of others, such as the expansion of the base at Fort Huachuca in southern Arizona.
Increasing autonomy of Indian tribes has resulted in accelerated development on many tribal lands including
mining, logging, tourist developments, and expansion of irrigation.

Several policy changes have occurred on resource lands managed by the US government. For
example, the US Forest Service has shifted from a policy than emphasized sustained yield timber harvesting
and multiple uses for timber, recreation, watershed protection and wildlife, to a more ecosystem
management approach. The Bureau of Land Management has tried unsuccessfully to raise grazing fees
from (1.60 per cow calf unit) in order to recoup management costs and reduce overgrazing. The National
Parks Service has been forced to implement people management in order to prevent overcrowding of parks
and other protected areas. All agencies have been affected by the Endangered Species Act that requires
protection and habitat management plans for species that are in danger of extinction.

Many of these policy changes have been challenged in the courts by those who wish to maintain or
expand the private benefit from federal lands whether it be low cost timber or cheap grazing leases. There
has also been a broader push to hand over federal lands to state or private ownership. This so-called
Sagebrush Rebellion has transformed into the Wise Use movement that believes that resources are better
managed and exploited in local or private ownership.

There is also growing opposition from the property rights movement that opposes “taking” of land
for environmental protection and federal or state interference in local land use policy.

E.3. Mexican Agricultural Policy

Mexican agricultural policy has been changing rapidly in recent years and has had important impacts
on land use and land tenure. The most important shifts include support for export crops and livestock, the
withdrawal of agricultural subsidies, the opening to international and US markets solidified by the North
American Free Trade Agreement (NAFTA), and the dramatic reversal of land reforms allowing the
privatization of ejido land.

The Mexican government has encouraged the production of grains, oilseeds, fruit and vegetables for
export through investments in irrigation districts, favorable support prices, credit for seeds and inputs, and
assistance with marketing and transport. Similarly, incentives have been provided for stockraising using
improved breeds fed with alfalfa and introduced grasses such as buffel.

Mexico’s program of trade liberalization gained momentum when it joined GATT in 1986 as part of
its effort to diversify exports away from petroleum products. During the decade, Mexico’s agricultural
exports to the U.S. more than doubled, from just over $1 billion in 1980 to almost $2.3 Billion in 1989
although the U.S. ran a net surplus in agricultural trade throughout this period ($3.3 billion for the decade).
Although some Mexican products compete directly with U.S. products, many others face little significant
competition while others, particularly fruits and vegetables, complement U.S. production as output peaks in
different seasons. In recent years, Mexico has been the leading exporter of fruits and vegetables into the
U.S. (supplying a sixth of the total in some years), starting under the General System of Preferences
program and continuing under NAFTA. Leading Mexican horticultural exports in the 1980s included
tomatoes, peppers, cucumbers, onions, melons and squash.

Implementation of NAFTA began on January 1, 1994, immediately eliminating all non tariff barriers
and some tariff barriers to trade in agricultural products with remaining tariffs to be phased out over periods
of five, ten or fifteen years. Under NAFTA, US exports of grains, including corn, wheat, rice and soybeans, have increased and are expected to continue to rise. US exports of cotton, pork, and chicken have also increased, putting pressures on Mexican producers. As tariff barriers continue to be eliminated (they still exist on corn, dried beans, and poultry, for instance), further surges in U.S. exports and related changes in Mexican production can be anticipated. The U.S. supplies approximately 7% of all of Mexico’s agricultural imports; its share was valued at over $5 billion in 1996.

The trade in both directions has expanded although U.S. agricultural exports have risen more rapidly than have Mexican exports to the U.S. The U.S. still imposes “safeguard” protections on Mexican exports of onions, tomatoes, eggplants, chili peppers, squash and watermelon. Although horticultural trade in both directions (the U.S. top crops are apples, pears and table grapes) is rising, Mexican exports to the U.S. of these products have expanded at a faster rate, particularly since the 1994 devaluation of the peso. Vegetable exports from the US are more than fruit exports from the US to Mexico. In 1997 Mexico accounted for more than $1.2 of $1.7 billion in fresh vegetable imports to the U.S. Tomatoes accounted for approximately $517 million of Mexican exports to the US and 80% of U.S. tomato imports.

It is important to note that Mexican agricultural policy is driven not only by a search for foreign trade through exports, but also by the needs of an expanding domestic market. Much of the expansion in vegetable, meat and dairy production is driven by demands from Mexico’s rapidly growing urban areas.

As a result of economic instability and staggering national debt, Mexican support for the agricultural sector more responsive to international competition and trade opportunities, recent administrations have altered or discontinued previous policies that offered considerable protection to the sector. Most of the government’s agricultural parastatals have been privatized. This has meant that Mexican producers are now facing market prices for many agricultural products and services such as fertilizer, commercial seeds, extension, crop insurance and credit. The system of price guarantees for many commodities has been changed, so that producer prices for crops such as barley, wheat, sorghum and other crops are closely aligned with international market prices. Although the price of maize and beans remains somewhat protected, they are gradually being adjusted to reflect the competition. In the 1980s, public investment in agriculture fell by more than 80% and rural credit by more than half. Subsidies on inputs such as fertilizer have been phased out.

In response to large increases in the number of agricultural loans in default and bank seizures of farmland during the 1980s economic crises, the government reformed the rural credit system. The public agricultural credit bank, BANRURAL, is now operating on commercial principles, with the effect that credit availability has declined dramatically in recent years, particularly for those producers with limited collateral or financial security.

In an effort to cushion some of the negative implications of these policy reforms for rural producers, the government has initiated a new agricultural program, PROCAMPO, that provides a direct payment of an established amount per hectare to each producer of basic crops (wheat, sorghum, maize, rice, barley, soya, cotton, sunflower, safflower and sesame). Although this program was intended to provide some support to the small-scale peasant producers of central and southern Mexico who were likely to be most adversely affected by increased competition from imported U.S. grains, many large-scale commercial producers are finding that the program enables them to continue the production of otherwise unprofitable crops. Thus PROCAMPO may be providing an incentive for large-scale producers in the northern states to continue to devote large areas of land to crops in the PROCAMPO program, rather than convert this land to other uses.

The economic crisis has directly affected agricultural producers who have sought private credit. In 1993, estimates of farm loans in default ranged from $1.3 billion to 4 billion and banks liberalization/competition, reduced subsidies, and a slow economy.
E.4. Article 27 and Land Reform

Article 27 and the Agrarian Reform Law of 1992, in the context of NAFTA and continued liberalization policies by the Mexican government, had the stated aim of ending public sector intervention and dependency in the agricultural sector, reversing the decreasing size but increasing number of landholdings, and stimulating modernization of agriculture with the cooperation of private (including foreign) capital. The primary components of this law included an end to redistribution of land (that has been blamed for reducing approximately $517 million of Mexican exports to the U.S. and 80% of U.S. tomato imports). (http://www.fas.usda.gov/htop/highlights/1998/98-04/fvimp97/98fvimp.html)

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As a result of economic instability and staggering national debt, Mexican support for the agricultural sector has been dramatically restructured in the last two decades. In an effort to make the sector more responsive to international competition and trade opportunities, recent administrations have altered or discontinued previous policies that offered considerable protection to the sector. Most of the government’s agricultural parastatals have been privatized. This has meant that Mexican producers are now facing market prices for many agricultural products and services such as fertilizer, commercial seeds, extension, crop insurance and credit. The system of price guarantees for many commodities has been changed, so that producer prices for crops such as barley, wheat sorghum and other crops are closely aligned with international market prices. Although the price of maize and beans remains somewhat protected, they are gradually being adjusted to reflect the competition. In 1980s, public investment in agriculture fell by more than 80% and rural credit by more than half. Subsidies on inputs such as fertilizer have been phased out.

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The economic crisis has directly affected agricultural producers who have south private credit. In 1993, estimates of farm loans in default ranged from 41.3 billion to 4 billion and banks were seizing farmers’ property, as the agricultural sector was squeezed by trade liberalization/competition, reduced subsidies, and a slow economy.

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blamed for reducing the incentive for private landholders to invest in improvements on their own land) and a transfer of property rights to the ejidos.

Under this law ejidos are permitted to sell land (with a two-thirds vote), to dissolve themselves and privatize, to enter into partnerships or rental agreements, and to use usufruct rights as collateral for commercial credit. Individual landholdings are still limited, while corporate landholdings are now permitted but restricted to 25 times the individual limit.

Ejidos have traditionally been controlled by a specialized government bureaucracy centered on agrarian reform, with a broad set of regulations and agencies influencing ejidal decisions. Since agricultural reforms started in 1991, ejidos have become more independent. Although still in the public domain, ejiditarios are more able to dictate what takes place on their own land. This includes the ability to use land as collateral for mortgages, to “individualize and privatize” ejidal lands, and to cooperate with private companies to develop the land. On the other hand, the ejido has, for most of this century, existed as a social and political unit, central to the national identity. Since the reform, no new ejidos are being created. Because no new land will be distributed in the form of ejidos, land under ejido control can only shrink. It is difficult to discern clear trends, as the process of land titling, carried out by PROCEDE, is off to a slow start and ejidos must pass through several stages of titling in order to form partnerships. It is clear, however, that ejidal land is already being privatized in both rural and urban areas, and that structural inequities and imperfect market conditions at times reduce the leverage that ejidos have in negotiating partnerships and contracts.

Although many studies have shown that small ejido plots are as productive as larger producers, the state’s withdrawal from the sector prior to the creation of functioning credit and input markets makes it likely that many of these small producers will leave the sector, particularly given the rapid reduction in tariffs and quantitative restrictions on imports. In many cases, however, observers predict that ejidos will retain their land, as the poor quality of much of it will make it unattractive to private capital (Alcala et al). Ejiditarios with larger landholdings are predicted to survive more readily than those with smaller, fragmented holding who are forced to seek off-farm employment to supplement their incomes.

E.5. Other important factor in Mexico

Important new elements in Mexican land policy are the changes associated with political democratization and decentralization. Over the last ten years, the domination of the PRI, the party that has ruled Mexico since the Revolution has been eroded by the growth of opposition parties and demand for fair elections. In the Chihuahuan Desert of Mexico, political change is evident in several opposition governors and in opposition votes at the municipal and local level especially for PAN right wing party.

At the same time moves have been made to decentralize decision making to state and municipal levels, including the enforcement and management of a number of environmental and land development programs. In most cases, inadequate financial resources have accompanied the new responsibilities.

Political action and social movements organized around environmental issues grew rapidly during the 1980’s, partly in response to the inadequacy of Mexico’s environmental laws, but also with encouragement from the government, which feared the rise of opposition political parties using green themes (Mumme, Bath et al., 1988). Mexico City and the US-Mexico border became the locus for the development of social movements around urban issues of crime and pollution, whereas rural movements focused on access to land, water and credit (Fowermaker and Craig, 1990). By the 1990s Torres reports 130 non-governmental organizations in Mexico City and 330 elsewhere in Mexico. [Torres, 1997 #2159].

By the end of the 1980s, public and political awareness of environmental issues was relatively high in Mexico according to a 1989 study conducted for UNEP, which surveyed 400 members of the public and 52 decision makers about environmental problems (Harris, 1989). The study found that 61% of the public and 88% of decision makers think the environment has become worse in Mexico in the last ten years; more than 80% of both groups felt this poses a great danger to human health. Mexicans had higher levels of concern about environmental issues than most other countries. More than 90% of both the public and
decision makers felt Mexico should be doing more to protect the environment and curb pollution, and that environmental protection should be a major priority for government. Again, Mexican attitudes were stronger than most other countries surveyed. However, 47% of the public and 23% of the decision-makers agreed that life in Mexico was so difficult that the environment was not a top concern.

Throughout Mexican history, agricultural production and economic development have taken precedence over forest conservation. Although some areas of Mexico were set aside as protected areas in the early 20th century, the combined land reform, agriculture and forest policy structure in Mexico has been a significant driver of land use and land cover change. Agricultural development policies, including direct investment in irrigation infrastructure for export agriculture and livestock production, agricultural credit, and a system of prices supports and producer subsidies, and limited availability of credit to the forest sector, have historically provided incentives for conversion of forest to other land uses such as agriculture, pasture and mining operations.

Recent changes in Mexican forestry policy attempt to correct the impacts of earlier policies that focused on extensive timber exploitation as a means to generate employment and economic development. The institutional and policy framework established in 1992 emphasizes greater conservation and sustainable management of forest resources. Modeled after the 1974 Chilean forestry law, the 1992 reform revised the legal framework previously in place in order to conform with the changes to Article 27 of the Mexican constitution and the agrarian reform program, thus opening the ejido sector to investment by both foreign and domestic companies while at the same time recognizing the value of allowing ejidos and communities to manage and control their own forest resources (Wexter and Bray 1995).

As discussed earlier in the paper, land reform and agricultural policies have undergone significant change since 1992. They system of price guarantees for most crops and producer subsidies (other than Procampo which will be phased out over a period of 11 years) has been eliminated. Banks are commercializing their operations, making credit more difficult to obtain. On the other hand, with increased state recognition of Mexico’s global biodiversity significance, incentives are being created by the Mexican government to promote sustainable forest stewardship. For example, the Ministry of Environment, natural Resources and Fisheries has passed legislation establishing financial and technical aid to forest ejidos and communities to help with developing a management plan, obtaining permits and reforestation activities.

While only 12% of the Chihuahuan Desert ecoregion is forest, these changes in forest policy can potentially have significant implications for land use and land tenure.

Conclusion