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The Political Ecology of Land-Use Change: Affluent Ranchers and Destitute Farmers in the Mexican Municipio of Alamos

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This paper examines the interactions between the environment, political and economic policies, and changes in land use and land quality by focusing on one region in northwest Mexico where dramatic transformations have occurred since the early 1970s. A political ecology approach is used to examine the nature and causes of environmental change at different scales of analysis, to address the importance of meanings assigned to ecological systems, and the effect of human-environmental interactions on natural resources. The objective of the study is to uncover the different circumstances under which farmers and ranchers have affected environmental change and how land-use decisions interact with political, economic, and environmental drivers through history. An emphasis is placed on the complexity of interactions between drivers and on understanding differences in perspectives between large-scale commercial ranchers, more diversified small-scale farmers and *ejidatarios*, bureaucrats, and environmentalists. The study concludes that strategies for reducing deforestation and developing reasonable community-based plans that promote sustainable livelihoods must consider the local and external causes of deforestation, the difficulty of environmental monitoring, and intraregional differences in environmental and socioeconomic parameters.

Key words: ranching, farming, deforestation, buffelgrass, Mexico

In the early 1970s an unprecedented change in land-use activities was initiated in Mexico's *municipio* (county) of Alamos, Sonora. Over the next 20 years, thousands of hectares of previously unused or underused land were cleared and transformed into pasture for livestock production. The introduction of buffelgrass (*Penniserum ciliare*), a variety well-suited for grazing in semiarid conditions, promised to turn this largely undeveloped municipio into a main producer of calves for the U.S. market. In the 1990s, rapid deforestation, environmental degradation, and loss of biological diversity became subjects of concern. Conservation biologists decried the environmental consequences of past modernization policies and underscored the ecological importance of the region as a critical transitional zone between three biogeographic regions—desert, coastal thorn scrub, and tropical deciduous forest. The Mexican government responded by establishing the Sierra de Alamos-Río Cuchujaqui Biosphere Reserve to restrict deforestation through a ban on forest clearing.

Today, two opposing ideological currents clash in the municipio's uneven territory. Whereas the logic of markets continues to advocate economic specialization in cattle ranching in a region in which this is not everywhere ecologically viable, mainstream environmentalism proposes limited use of natural resources without giving adequate consideration to the impact of those decisions on rural livelihoods. Caught in the middle are thousands of agricultural producers. In this paper we seek to uncover the different circumstances under which they have affected environmental change in the municipio. We ask how natural resources have been influenced by people's decisions and how processes of sociocultural and ecological change occurring in the Municipio of Alamos are linked to the restructuring of global livestock and agricultural markets. We also examine the multiple meanings of emerging environmental ideologies, their interplay at the local level, and their impact on resource management.

The situation we explore in this paper is not unique. Deforestation, overgrazing, and the tensions resulting from contradictory policy objectives constitute significant global-scale changes in rural life, changes whose consequences remain uncertain (Toledo 1996; Ezcurra et al. 2001). Because drivers of environmental change generally occur at the local level, an empirically informed understanding is

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required. Political ecology has made important contributions in this regard by examining local processes within the context of global environmental and socioeconomic change (Stonich 1995; Painter and Durham 1995). Although some authors argue that political ecology must "favour consideration of the political over the ecological" (Bryant and Baily 1997: 6), those more interested in offering practical solutions to complex environmental problems emphasize that political ecology also must consider carefully the nature and causes of environmental changes (Vayda and Walters 1999), the importance of meanings assigned to ecological systems (Rocheleau, Thomas-Slayter, and Wangari 1996), and the effect of human-environmental interactions on natural resources (McGuire 1997).

Our analysis is rooted in a political ecology that, as suggested by Escobar (1999:3), "acknowledges equally the cultural and the biological" and examines how the biophysical is instituted into history. This approach has the potential to find answers that have practical implications for resource management, if, as suggested by Blaikie and Brookfield (1987:16), it takes as its point of departure "the direct relationship between the land-user and manager and the land itself" and then goes on to find relevant links at local, regional, national, and international levels. This requires that we incorporate the perspectives of the people who are directly affected by and affecting change. We must pay attention to how people with different resource endowments, technologies, and economic and policy incentives use resources and perceive ecological systems as well as their differential impact on the natural environment. We also must examine emerging environmental agendas as part of a larger social context, rather than from a moral perspective (Pulido 1996). These are internal and external to the communities, have multiple meanings, and affect land-use decisions in different ways (Sundberg 1998).[1]

Finally, a political ecology approach requires a more balanced approach to understanding the interrelationships between human agency and large-scale structures. Even though political economic structures influence local producer's land-use decisions, the latter constantly resist, contest, and recreate those structures (Stanford 1990; Burt 1997; Vásquez-León 1998). Through this process, local agents are capable of modifying not only the natural environment, but also larger political, ideational, and economic structures, which, in turn, limit and promote human agency (Lansing 1999:208).

We begin with a brief background describing the Municipio of Alamos' physical environment, history of resource use in the region, and demographic characteristics. We then take a more detailed look at the resource users themselves, at their responses to larger policy and economic issues, and we make a preliminary attempt to examine the impacts of local land use on the physical environment. Finally, we look at environmentalism and at the various perceptions of land degradation and deforestation as they relate to economic concerns.

A Note on Methods

Demographic, economic, and agricultural statistical data from Mexico's national data institute, Instituto Nacional de Estadística Geográfica e Informática (INEGI), were used to create socioeconomic profiles of the region and obtain a quantitative measure of land-use change between 1970 and 1990.[2] Ethnographic and ecological assessments were employed to gather qualitative and quantitative data on the condition of the ecosystem, the management of land, economic activities, and perceptions of land use.

A team of researchers went to the study site on four different occasions throughout 1997 for periods ranging from two weeks to two months. During our initial visit in the spring, we identified a variety of stakeholders, including municipal officials, technicians and leaders from different government and private organizations, cattle ranchers' associations, and peasant organizations. Producers in the main economic sectors within the municipio were also identified: private ranchers, *ejidatarios* (communal land users), miners, and wood collectors. This information was then used to decide who should be interviewed within each sector.

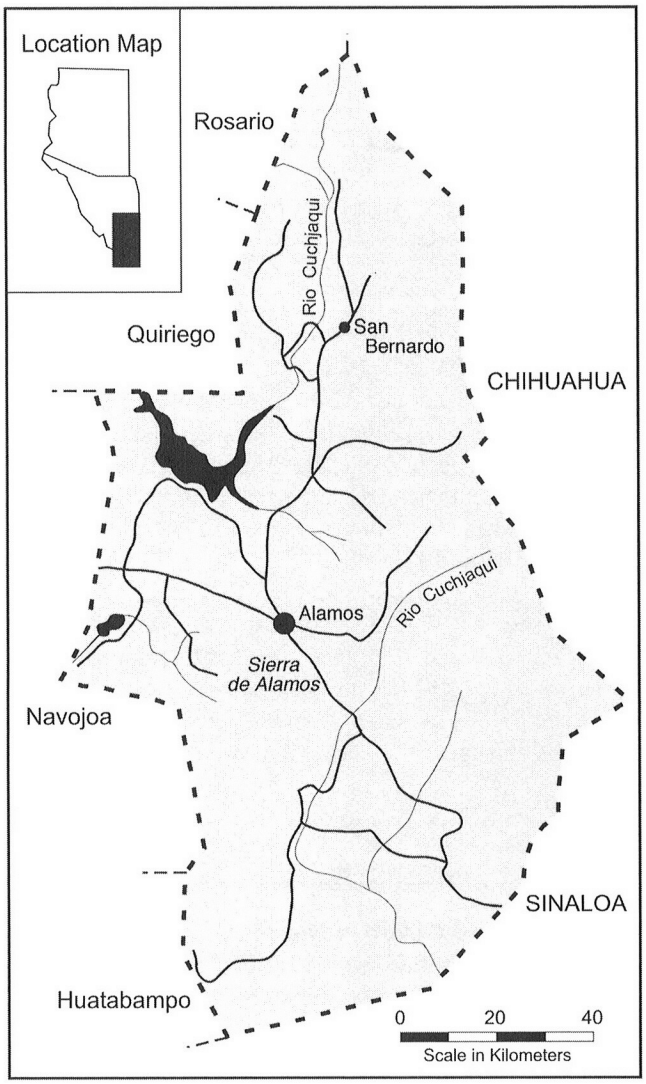
Most of the fieldwork was carried out during the summer months. The team conducted over 70 open-ended interviews with residents of the municipio, officials, scientists, and producers from different sectors. Using ethnographic techniques, information was collected on the organization and management of land, forest, and animal resources. We also focused on central aspects of community life, such as patterns of employment, entrepreneurial activities, land tenure, and migration patterns. These ethnographic efforts relied on standard methods of participant observation, which involved an array of data-collection methods. These included observation and various kinds of interviews—informal conversations, formal sessions with carefully chosen people in different sectors, and focus group interviews used to elicit diverse opinions on controversial issues. In-depth interviews were conducted with a variety of individuals who, during the process of fieldwork, revealed an unusual depth of relevant knowledge and willingness to talk. Throughout the research, snowball sampling techniques were used to select interview and focus group participants.

Information also was derived from satellite images from NASA's North American Land Cover dataset (from 1973, 1986, and 1992). These were used to examine general changes in the structural, spatial, and environmental parameters of the study area, as well as to initiate conversations about the spatial patterns of land ownership and use. Survey emphasis was placed on the localities indicated by the satellite images as having undergone the greatest change.

The Physical Environment

The Municipio of Alamos lies in southeast Sonora, within the physiographic provinces of the Sierra Madre Occidental and the arid western coastal plains of the state of Sonora (Figure 1). It encompasses a total of 6,947.47 square kilometers

Figure 1. Municipio of Alamos, Sonora, Mexico



Source: Burt 1997.

and has three distinct biophysical regions—the Sierra, semiflat lands, and flat lands—which impose different constraints on natural and human-adaptation processes. The largest of these regions, the Sierra, covers 60 percent of the municipio's territory and is located to the north and east of the municipio. This mountainous area, where pine and oak woodlands predominate, ranges in elevation from 800 to 2,000 meters. Despite abundant rainfall, with an annual mean of 700 millimeters, the region has few possibilities for agriculture. Because of the ruggedness of the terrain, susceptibility to erosion is high and accessibility is difficult (Gobierno del Estado de Sonora 1993). Since the 1600s, the Sierra has been mostly inhabited by Guarijío Indians who have subsisted by combining slash-and-burn agriculture, hunting and gathering, and limited livestock and commerce (Camou-Healy 1985).

Semiflat areas, found scattered throughout the municipio, encompass about 30 percent of the territory. These are transitional zones of oak woodland and tropical deciduous forest where mean annual precipitation is 602 millimeters. These areas are characterized by hills averaging 500 meters and narrow alluvial floodplains formed by streams along the Mayo and Cuchujaqui Rivers, the principal sources of water for the municipio. Floodplains form pockets of arable lands, which have supported small and scattered settlements of diverse Indian groups since prehistoric times (Spicer 1962). Today, anthropogenic disturbances in semiflat areas—agriculture, ranching, and harvesting of timber—have led to profound alterations to the natural vegetation cover (Municipio de Alamos 1989).

The remaining 10 percent of the territory is flat lands, which tend to be located in the west-central region around the city of Alamos and to the south of the Sierra de Alamos. These form *mesetas* (plateaus) and valleys that reach an elevation of 350 meters and are intersected by numerous streams. Aridity is the greatest limitation at these lower elevations, where mean annual precipitation is 432 millimeters and daytime summer temperatures often go above 40° Celsius. The vegetation—thorn scrub, semidesert grasses, and some deciduous forest—is transitional between the Sonoran desert species and the dry tropical forest (Gentry 1942). Flat lands contain the greatest concentration of human settlements, the most fertile soils, and have undergone the greatest amount of change (Gobierno del Estado de Sonora 1993).

Due to a lack of irrigation infrastructure in the municipio—less than 1 percent of the land is irrigated, making the municipio the largest rain-fed agricultural area in Sonora (Gobierno de México 1997)—farmers and ranchers rely on highly variable and extremely localized seasonal precipitation patterns. About two-thirds of the annual precipitation falls between July and September. Torrential rains sometimes cause flooding, damaging fields and making roads to settlements at higher elevations inaccessible. Scattered light winter rains occur from November through February and are followed by a four-month dry season. Rainfall patterns restrict local farmers to cultivation of one crop per year, but high year-to-year variability has led to diversified livelihood systems in which farming is combined with ranching, forestry, and off-farm activities.

The topography and erratic availability of water over time and space present significant environmental constraints for producers in the municipio. This becomes evident when looking at land use. Of a total of 694,892 hectares, in 1994 only 25,466 were used for rainfall-dependent agriculture, 304 for both rain-fed and irrigated farming, and 32,000 for cultivated pasture. The rest of the municipio—about 637,122 hectares—can be utilized only as *agostadero* (pasture) or for nonagrarian activities such as mining and forestry (INEGI 1994).

A History of Land Use: Mining and Cattle Ranching

The history of cattle ranching in what is today the Municipio of Alamos began with the discovery of rich silver

deposits in 1683. By the end of the 1770s the Alamos district was producing nearly two-thirds of the silver in Sonora and Sinaloa, had become the center of Spanish settlement in northwest Mexico, and had close to 8,000 residents (West 1993). Mining attracted a permanent labor force and new forms of land use. Mesquite and oak trees where exploited for timber and charcoal, mine workers established communities dependent on small-scale agriculture, and Spanish settlers introduced large haciendas and stocks of *criollo* cattle—varieties of North African origin well adapted to arid conditions (Voss 1982).

This period of economic domination ended abruptly with the closure of mining operations after the Revolution of 1910. From then on, the focus of government policies shifted from the mountainous eastern region of Sonora to the development of large-scale commercial agriculture in the western coastal plains (West 1993). It was argued that, due to its rugged terrain, developing eastern Sonora would be unprofitable. Instead, irrigation water had to be brought to the neighboring coastal valleys for the development of commercial farming. This meant that Sonoran rivers, which originate in the eastern sierras, had to be diverted (Dunbier 1968). For the Municipio of Alamos, this shift in policy had grave environmental and economic consequences.

During the land-reform years (1934-1940), even though more than 75,000 hectares of land were distributed among the municipio's 25 ejidos, land came without water and national programs of small irrigation infrastructure were not undertaken in Sonora (Sanderson 1981). Instead, the Secretaría de Recursos Hidráulicos (SARH) built a dam to control the Mayo River's discharge for irrigation in the coastal valleys of the adjacent municipio of Navojoa (Guadarrama et al. 1985). Similarly, a ban on well drilling was declared in the municipio and waters from the Cuchujaqui River had to be allowed to flow south to a dam located in the state of Sinaloa.

The development of commercial agriculture in the coastal valleys attracted migrants from the Chihuahuan sierras who settled in the municipio, practicing small-scale agriculture and working as seasonal farm labor in the neighboring irrigation districts. By 1930 the municipio had 18,000 residents and cattle ranching was becoming increasingly important. As elsewhere in Mexico, private-sector producers, as opposed to those in the ejido or social sector, disproportionately benefited from state development policies (Camou-Healy 1985). For example, the 1947 amendment to the constitution allowed individual private ranchers to possess enough land to support 500 head of cattle (Sheridan 1988). In sharp contrast with northern Sonora, where private ranchers had been producing for the U.S. market since the beginning of the 20th century (Sheridan 1988), through the 1960s most of the cattle in the Municipio of Alamos continued to be sold nationally; commercial ranchers practiced an open-range system and combined livestock with agriculture (Peña and Chávez 1985).

It was not until the 1970s that the municipio became an integral part of rural development policies. In response to high market prices for calves in the U.S., the Mexican state, through entities such as SARH, introduced European cattle varieties. Because these are not well suited for semiarid environments and require more water and better nourishment, buffelgrass pastures, which produce more forage than native species, were introduced to counteract the problem.[3] This African grass, first brought to Sonora in 1958, was seen as ideal for the semiarid municipio. According to the Patronato del Centro de Investigaciones Pecuarias del Estado de Sonora (PATROCIPES 1995:2), "buffelgrass has meant the greatest transformation and evolution for Sonoran ranching in this century." Even though the Municipio of Alamos lies outside the area recommended for buffelgrass cultivation, government policies attracted private investors, motivated the creation of livestock ejidos, and encouraged existing agricultural ejidos to expand their production of cattle. Alamos became the fourth leading producer in the state, as the number of cattle increased from 63,164 head in 1960 to 115,000 in 1983 (Gobierno del Estado de Sonora 1993).

These changes led to rapid environmental transformations. As shown in Figure 2, comparison of INEGI's land-use data from 1970 and 1990 indicates that the municipio lost 80 percent (107,230 hectares) of its forest cover,[4] land in cultivated pasture increased from 0.8 percent of total area to 5 percent, and agostadero land increased from 55 percent of total area to 82 percent. In contrast, cultivated agricultural land fell from 11 percent to only 4 percent. This pattern of

Figure 2. Land Cover in the Municipio of Alamos, 1970-1990

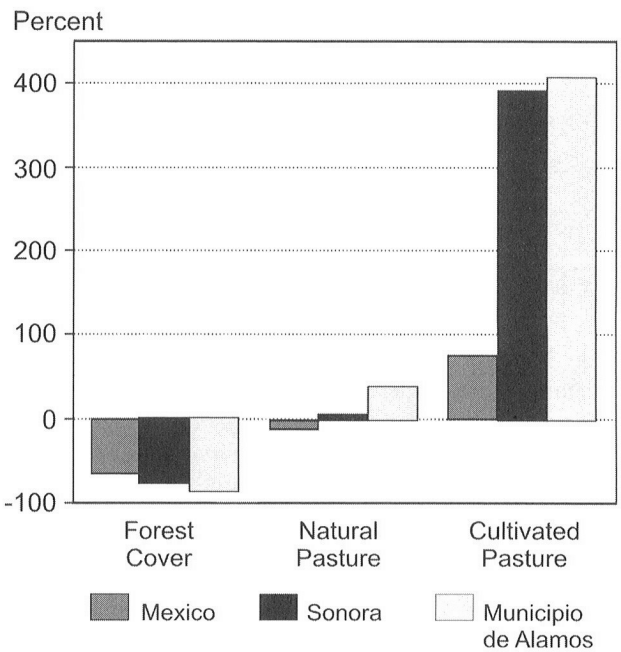


Table 1. Private Commercial Ranchers and Ejidatarios, Socioeconomic Indicators

Variables	Private Commercial Ranchers	Ejidatarios
Number of ranchers	30% (610 units)	70% (1,428 units)
Number of cattle owned	60% (41,223 head)	40% (27,656 head)
Type of cattle	European varieties	Mostly criollo varieties
Grazing	Agostadero and cultivated pastures	Mostly agostadero lands
Economic importance	High, year-round activity	Combined with farm and off-farm activities
Number of agr. producers	20% (596 units)	80% (2,386 units)
Land ownership	63% (29,568 ha)	37% (26,253 ha)
Land use	Cultivated pastures	Subsistence and market crops
Farm size > 100 ha	50%	4.5%
Farm size < 20 ha	1%	91%

change was similar to that experienced in Sonora, where land in cultivated pasture grew from 30,000 hectares to almost 150,000 hectares over the 20-year period (INEGI 1990).

While population in the state of Sonora increased by 65 percent from 1970 to 1990 (Pick and Butler 1994), population in the municipio increased by 0.5 percent during the same period. Escalating incentives for cattle production led to an initial increase in population from 24,170 in 1970 to 29,091 in 1980. This trend reversed in the 1980s, however, as a combination of factors, including Mexico's general economic crisis, severe land degradation, and extended drought, led to an actual drop in population to 24,302 in 1990 (INEGI 1996a, 1996b). Today 42 percent of the municipio's economically active population depends directly on ranching and agriculture, and its population of 25,152 is dispersed in about 300 communities, most with less than 1,000 inhabitants. The largest urban area is the city of Alamos, with 14,063 residents (INEGI 2001).

Distribution of Resources and Livelihood Systems

Some argue that despite its benefits, the technological changes that came with the introduction of buffelgrass brought negative consequences. In ecological terms, the transformations resulted in the alteration of habitat and subsequent elimination of the most characteristic plant and animal species. In the Sierra, erosion and landslides became increasingly problematic, and in areas where edaphic conditions were unsuitable, the soil was quickly depleted of nutrients (Robichaux and Yetman 2000). Only a relatively small portion of private sector producers were able to benefit fully from programs promoted by the federal government, contributing to an increase in the gap between small and large ranchers.

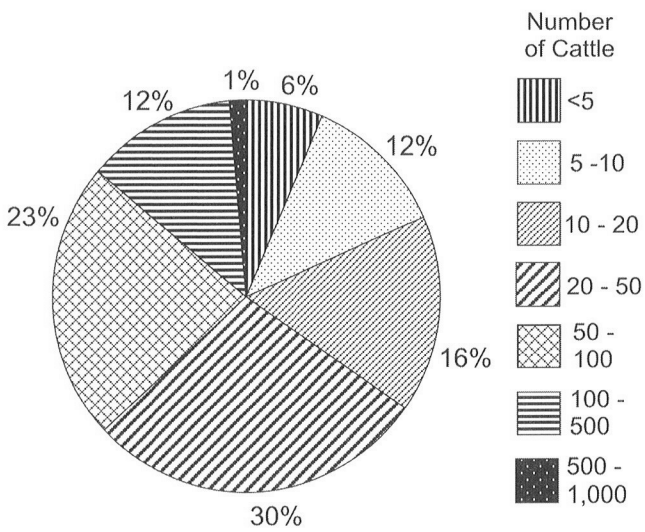
This unequal pattern of resource distribution is summarized in Table 1. At one end are the highly specialized producers of yearling calves. Large-scale commercial ranchers are mostly private-sector landowners who have converted sizeable areas of natural vegetation into buffelgrass pastures. Although they constitute 30 percent of the municipio's livestock producers, they own 60 percent of the cattle. But within this sector, there is considerable variability (see Figure 3).

According to the census, only 1 percent of private ranchers own at least 500 head of cattle, and 34 percent own less than 20 head. Like the ejidatarios (communal land users) described next, this latter group of small private producers combine livestock with dry farming and are referred to in this paper as small landowners. Although ejidatarios account for 70 percent of the municipio's producers, they own only 40 percent of the cattle, and 75 percent own 20 head of cattle or less. For ejidatarios, cattle ranching is a secondary activity, and grazing is done mostly in agostadero land (INEGI 1996b).

The distribution of arable land in the municipio is also highly skewed. The 1996 census indicates that 6.7 percent (47,126.69 hectares) of the area is under cultivation, including cultivated pastures. Although only 20 percent of agricultural producers are in the private sector, they own 63 percent of all arable land, and almost 50 percent of farms are bigger than 100 hectares. In contrast, ejidatarios amount to 80 percent of all producers but control just 37 percent of arable land. The vast majority, 91 percent, have farms of 20 hectares or less.

Within this range of producers there is considerable variability in the intensity with which resources are used and managed, the amount of land cleared for cultivation of pastures, and the impact on the natural environment. There are also differing perceptions of deforestation and environmental degradation. For some conversion to buffelgrass pastures is a positive economic factor, for others deforestation has led to

Figure 3. Distribution of Cattle among Private Ranchers



erosion and rapid land degradation, diminishing their productive options. A closer look at the municipio's livestock and agricultural producers reveals these differences.

Large-Scale Commercial Ranchers

Those who specialize in the export of high-quality yearling calves for the U.S. market tend to live off cattle ranching throughout the year, have at least 200 hectares planted in buffelgrass, and own enough land to maintain at least 500 head of cattle (personal communication, president of the local cattlemen's association, August 18, 1997). Compared to ejidatarios and small landowners, commercial stockmen own the largest expanses of flat lands. They also have better access to markets and a vastly superior ranching infrastructure. This allows them to better conserve their rangeland and to practice the latest techniques of livestock breeding. Despite variability—some are absentee landlords, others highly diversified businessmen, and still others are hard-working ranchers—most belong to large ranching associations and have received the bulk of government support, including credit, subsidies, technical assistance, and emergency relief aid. Such aid is significant, given the high costs of establishing and managing buffelgrass pastures. In 1997, local producers estimated initial investment costs at around 2,000 pesos ($260) per hectare. This included the purchase of seeds, the clearing of land—a machine-intensive operation that may involve bulldozers—and the plowing of fields to around 30 centimeters. Once planted, it takes two to three years for the prairies to become established and productive. Then the intensive grazing of cattle can be initiated. In addition, to maintain soil quality,[5] buffelgrass must be burnt periodically and replanted every six years.

The relative economic success of commercial stockmen hides the mixed impact of specialized ranching on the local environment. The satellite images presented in Figures 4 and 5 compare land cover in 1973 and 1992. Because flat surfaces facilitate land clearing and reduce risk of erosion, investment in buffelgrass cultivation concentrated in the west-central and south-central regions. The degree of success, however, varies between the two and is associated with the intensity of management and specific climatic and edaphic conditions (Ibarra-Flores et al. 1999).

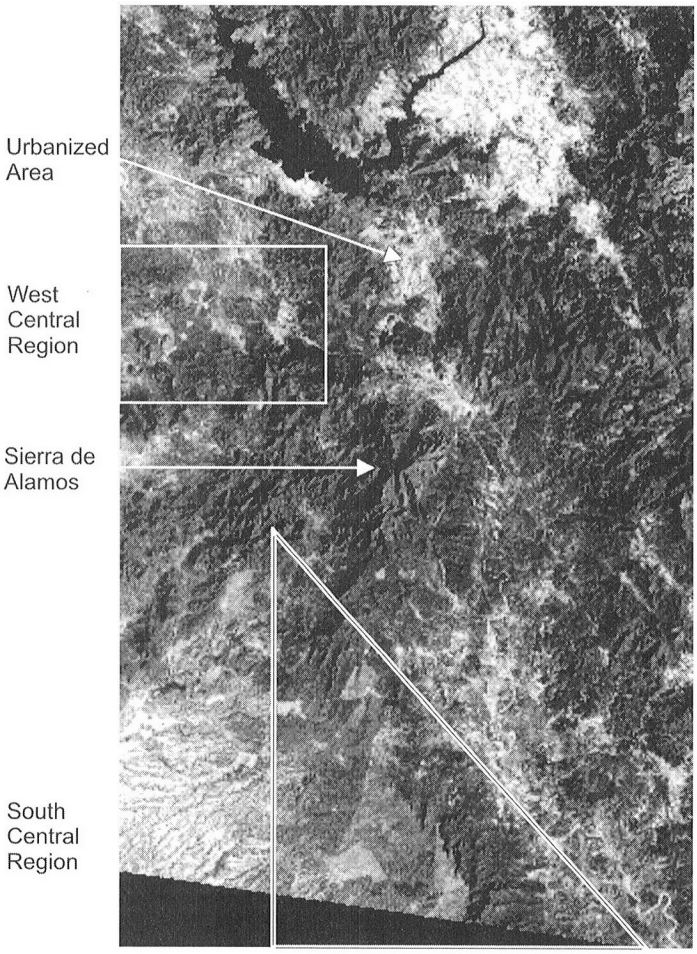
The west-central region has the largest and better-established buffelgrass pastures. This region shows a cumulative process of change in vegetation, which, as ground observations indicate, can be directly associated with the intensification in livestock activities. In addition to flat surfaces, this region has coarse and sandy soils that are well suited for buffelgrass. An average of 228.6 millimeters of rain per year leads to higher productivity than the drier areas of northern Sonora. The combination of these physical characteristics attracted relatively more and sustained capital investment to the region.

The south-central region combines lands cleared for buffelgrass in the 1970s, but later abandoned, and large ranches with well-established pastures. According to an agronomist from the Secretaría de Agricultura y Desarrollo Rural (SAGAR), between 1974 and 1976 hundreds of hectares of land were bulldozed in this area as wealthy urban investors took advantage of government subsidies. Although many saw buffelgrass as an opportunity to diversify their economic investments, they had no ties to the land and, in the words of the SAGAR agronomist, "just took advantage of the credits, cleared but never planted and pocketed the money instead." Poor edaphic conditions contributed to failed attempts. This region contains sizeable stretches of expansive, clayey soil, which expands during rainy periods and contracts during the dry season. This cracks and breaks the roots of the buffelgrass, which can grow five to six meters under the ground.

Bowden and Dykinga (1993) emphasize the detrimental environmental consequences of clearing land, cultivating, and then abandoning pastures. Whereas hand clearing of land for subsistence agriculture does not permanently damage the forest, because trees will eventually regenerate, bulldozing tree stubs will lead to dense grass cover that prevents germination or seed establishment, and the forest will not recover. In addition, when the grasslands are abandoned in regions of low growth or deciduous forest, the semitropical thorny scrub called chirahui (*Acacia cochliacantha*) takes over. Chirahui is a common tree that thrives in uniform stands as second growth and is one of the few plants able to compete successfully with buffelgrass (Robichaux and Yetman 2000).

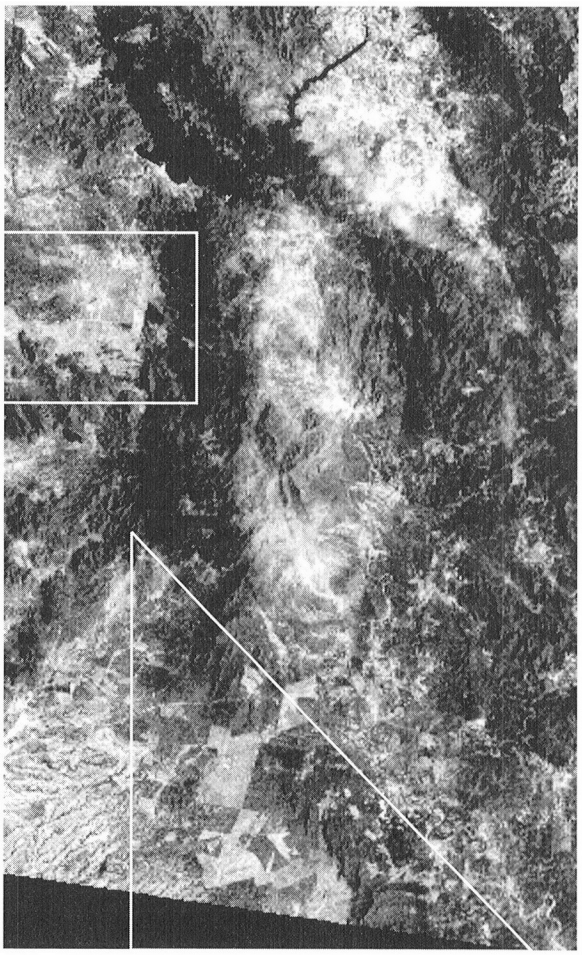
The Chiragui invasion in the south-central region makes it difficult to identify vegetation changes through satellite images, but ground observations clearly indicate disturbance. Even pastures abandoned for two years were covered with chirahui. In contrast, vegetation changes in areas of successful

Figure 4. Municipio of Alamos, 1974™



Source: NASA, 1973

Figure 5. Municipio of Alamos, 1992™



Source: NASA, 1992

establishment are easily identifiable through remote sensing. Figures 4 and 5 indicate persistent clearings in the southern tip of the municipio, which contains several clusters of large private ranches. After more than 20 years of experience with buffelgrass, today's successful commercial ranchers are aware of the importance of understanding edaphic conditions when choosing a planting site. As one older rancher stated, "buffel must be planted only in land that can sustain it, otherwise land should not even be cleared in the first place. In good lands for buffel the grass grabs on to the soil, otherwise it does not succeed."

Ranchers also have become aware of the grass's sensitivity to climatic variability. Although buffelgrass adapts well to semiarid conditions, without any rain it dries up quickly, does not provide adequate nourishment, and cattle do not find it "tasty." This became evident in the 1990s when severe droughts devastated rural economies in northern Mexico (Chávez 1999; Liverman 1999). In 1995, an absence of winter precipitation led to 10 consecutive months of drought. Those who had converted large tracts of land into buffelgrass pastures suffered the greatest economic losses, but ranchers who maintained diversified pastures faired better. As an older rancher argued, "When diversity in nature is destroyed, the long-term consequences can be devastating." Although less productive, native grasses do well with little rain and may in fact rot during the rainy season (García Zamacona 1990).

After the drought of the 1990s, scientists who had recommended converting as much land as possible into artificial pastures in the 1970s advised that buffelgrass pastures should only be established in 15 percent of the total area. This would increase animal carrying capacity while allowing ranchers "to maintain a productive pasture and improve the ecological condition of the native species of natural vegetation" (Johnson and Navarro 1992:119). The holistic management method now is being promoted by government agencies (PATROCI-PES 1995), the cattlemen's association, and by large private

ranchers who have experimental plots on their land. Many have also gone back to cultivating sorghum as forage, while others have diversified into poultry and pig operations. These and other adaptations have lowered rancher's vulnerability to local environmental variability.

Ejidatarios and Small Landowners: Ranching, Farming, and Forestry

The majority of producers in the municipio (ejidatarios and small landowners) combine dry farming, small-scale cattle ranching, and off-farm activities. They are found throughout the municipio, but tend to concentrate in semiflat areas. Among ejidatarios and small landowners, ranching is often a subsistence activity. Grazing is generally on agostadero lands, criollo varieties predominate, cattle are sold domestically, and, except for three livestock ejidos with large expanses of flat lands located in the southwest and west-central parts of the municipio, most have little or no buffelgrass pastures. Even though agostadero lands provide a variety of vegetation through most of the year, overgrazing, which increases vulnerability to seasonal changes in precipitation, is a major problem (García Zamacona 1990). Although the grazing ratio recommended for agostadero lands in the municipio varies between 18 and 42.5 hectares per animal unit based on total land area (Municipio de Alamos 1989), local SAGAR agronomists estimate the actual ratio to be 7.1 hectares per animal unit.

The severity of overgrazing partly depends on topographic conditions and water availability. Because cattle cannot climb to higher elevations, producers tend to graze their cattle in semiflat and flat lands, where precipitation is lower. For those situated near permanent water sources, overgrazing is less of a problem because cattle is more evenly distributed throughout the agostadero. For ejidos that have water troughs that dry up in the spring, water must be hauled in buckets during the dry season, concentrating cattle and intensifying grazing in small areas.

Virtually all small producers in the region grow agricultural crops to supplement family diets, to feed their cattle, and to sell for profit. Corn, beans, and squash are produced for household consumption, and sesame, peanuts, and sorghum are produced for the market, mostly to meet basic needs. Economic reliance on rain-dependent agriculture has led to a pattern of cyclical out-migration during the dry season, from December to May. According to local residents, most farming households seek wage employment in the neighboring coastal irrigation districts (also see García Zamacona 1990), or in the maquiladora industry at the U.S.-Mexico border. During years of drought and economic downturn the cycle of migration intensifies, especially in settlements located in the Sierra.

Lack of credit and inconsistent government policies remain significant limitations for ejidatarios, with grave consequences for the natural environment. A substantial infusion of credit to livestock ejidos in the 1970s led to the initial clearing of land and establishment of buffelgrass pastures. In 1985, the largest ejido in the municipio had managed to cultivate 2,000 hectares in the west-central region. At the end of the 1980s, government incentives began to dwindle when Banrural, the public-sector bank and main source of credit for ejidatarios, left the municipio. Thousands of hectares of buffelgrass pastures were abandoned as credit became less accessible and ejidatarios lost the financial capacity to manage them. Even ejidos located in suitable areas gradually saw their grasslands invaded by chirahui, and the number of cattle diminished as credits continually arrived late. For those in the Sierra, the government incentives of the 1970s, which also promoted land clearing for buffelgrass pastures on steep slopes, led to erosion, increased incidence of landslides, and widespread invasion of chiragui.

Through the 1990s structural adjustment reforms increased uncertainty. The most drastic of these was the 1992 modification to Article 27 of the Mexican Constitution, which allowed the privatization of ejido lands (Otero 1996). The Programa de Certificación de Derechos Ejidales (PROCEDE) was established to support land privatization, but by the end of the 1990s most ejidatarios in the municipio had not received title to their land and had not been visited by PROCEDE officials. The consequences of this contradictory process were bitterly explained by an ejidatario:

> If you are an ejidatario your credit history is completely irrelevant, what matters instead is that you have land to put as collateral. That has been one of the ejido's worse problems. We don't have individual title to the land, we are temporary and no private bank wants to issue us credit. They certainly won't give us credit for a cow, unless you sell it, and without credit, the prairies are getting invaded by chirahui.

This uncertainty of land tenure contributed to overgrazing, lack of management of grazing areas, and low investment in infrastructure.

With the implementation of the North American Free Trade Agreement (NAFTA) in 1994 and corresponding free-market policies, imports of meat have increased and prices for cattle sold domestically have declined. According to a local official: "Prices have gone down, you used to get eight pesos per kilo in the 1980s, now its four pesos. There are ranches for sale all over and no one to buy them." With the exception of a few agricultural subsidies such as PROCAMPO, which is a direct cash subsidy, government subsidy programs are geared to large-scale commercial operations and require significant investments of money and time before government reimbursements are received (see De Janvry et al. 1996). Ironically, planting a few hectares of buffelgrass has become imperative for ejidatarios to get through the dry season and reduce pressure on agostadero lands. But ejidatarios know that without access to credit, they simply do not have enough capital to initiate and maintain pastures.

Whereas in the past the ability to save and diversify was an important strategy to minimize risk, today lack of credit,

coupled with drought, land degradation, and decline in the price of cattle, have resulted in abandonment of land and permanent out-migration, especially in the Sierra. For land-poor households that have stayed, small-scale wood collecting is becoming an increasingly important source of secondary income. The 1995 census indicates there are 77 small private sawmills in the municipio and 2,535 households within ejidos that derive part of their yearly income from wood collecting (INEGI 1995). Official timber production records indicate an increase in productivity from 6,000 cubic meters in 1987 to 18,000 cubic meters in 1990 and a sharp decline to less than 5,000 cubic meters in 1992. These figures, however, do not account for illegal harvesting and are therefore misleading (see Harvey 1996 and Vásquez-León 1998). According to local residents, illegal harvesting rose during the 1990s as regulatory efforts aimed at reducing deforestation and protecting such tree species as vara blanca (*Croton niveus*) became more restrictive.

Vara blanca is used for tomato and grape stakes in Northern Mexico and has high, year-round market demand, which makes it an attractive economic alternative after the agricultural season when supply peaks. The tree is found only in the tropical deciduous forest of the municipio and in a small portion of northern Sinaloa (Lindquist n.d.) and, thus, is of particular concern to environmentalists.

Local cutters also are concerned about an increase in wood harvesting as the region's economic and environmental conditions deteriorate. As one cutter explained, "Right now the exploitation of vara blanca is affecting the vegetation, too much wood is being cut, but there is a great deal of need. We need alternative sources of income because today vara blanca is our investment for the future, if we finish it off, then we are all going to have to leave." This concern has led cutters to initiate conservation efforts on their own, including a campaign to keep cattle away from large populations of vara blanca.

Economic Versus Environmental Concerns

The Mexican government expressed official concern for the ecology of the Municipio when, in 1996, it established the 96,000-hectare Sierra de Alamos-Río Cuchujaqui Biosphere Reserve (Valle 1996). The creation of the reserve was Mexico's way of partly furthering the cause of "conservation and development," which became a prerequisite for the signing of NAFTA. In response to environmental interest groups in the U.S. and Mexico, which denounced the lack of environmental provisions in the treaty, an environmental side accord, the North American Agreement on Environmental Cooperation, was endorsed in 1993. The Alamos reserve became part of Mexico's Program of Protected Natural Areas, 1995-2000 (Secretaría del Medio Ambiente y Recursos Naturales [SEMARNAT]), which included 95 other protected areas (Wexler and Bray 1996).

The reserve also was a response to the rapid deforestation and conversion to buffelgrass that began in the 1970s (Robichaux and Yetman 2000). As environmental conditions deteriorated in the region, a new and growing constituency of "nontraditional" interests, including environmental nongovernmental organizations (NGOs) and conservation biologists from Sonora and the U.S. Southwest, began pressing state organizations in the direction of a more activist role in alleviating environmental resource problems. Concern for the future of the dry forest motivated the Centro Ecológico de Sonora (CES) to propose the reserve, with financial backing from the U.S. Agency for International Development (USAID) and The Nature Conservancy and with the endorsement of SARH, the Municipio of Alamos, the Secretaría de Desarrollo Urbano (SEDUE), and the Centro de Ecología, Universidad Nacional Autónoma de México (UNAM) (CES 1993). The creation of the reserve led to a change in the local power structure, as a new set of actors entered the municipio with the authority to design and enforce regulations that have a direct impact on rural livelihoods. Suddenly, modernization, development, and buffelgrass became synonymous with environmental destruction.

The reserve's principal objective is to restrict deforestation in the dry tropical forest for the conservation and protection of major species of plants and animals, mainly invertebrates and reptiles (SEDESOL 1994). This includes prohibiting productive activities, mainly ranching, farming, and wood collecting, in areas considered of "critical biological importance," restricting and supervising productive activities in areas of "lower biological importance," and encouraging such alternative economic activities as ecotourism in localities of "natural beauty" such as riparian areas (CES 1993:95-96). In particular, environmentalists denounce the detrimental environmental impact of buffelgrass cultivation. They argue that buffelgrass depletes the soil of nutrients, monopolizes the ecology of the region through fire regimes, decreases biodiversity, and, in a few words, takes over (Yetman 1993). Yetman and Búrquez (1994:8) emphasize the negative consequences of the grass's susceptibility to burn: "Sonorans have learned one peculiar and painful fact about buffelgrass, it loves fire and burns like a torch.... The dried grass helps fires spread. Then it moves in when the competition has died, choking out all other aspiring plants." In addition, they argue that because buffelgrass is not adapted to prolonged dry periods, it exceeds the long-term sustainability of the range.

But the reserve has potential pitfalls. It is crossed by the Cuchujaqui River, contains 37 percent of the municipio's total population (CES 1993), and, according to the reserve's management team, 90 percent of the area is held by ejidos and private interests that are not amenable to conservationist goals.[6] In addition, financing for the reserve must come from private sources, and, at the time of our research, there were only four part-time extension agents responsible for management. Thus, successful conservation is dependent largely on local residents and their perceptions of the environment and economic priorities.

Even though the ranchers and extension agents interviewed in the municipio recognize the negative environmental

implications of deforestation and conversion to pasture, they disagree with some of the arguments made by environmentalists and contend that the environmental impacts of buffelgrass are not uniform throughout Sonora. They maintain, for example, that buffelgrass does not invade where there is a dense canopy.[7] Instead, it tends to persist at the seeding site or, in unsuitable soils, declines with time and dies. Also, although fires spread by buffelgrass appear to be a major problem in the more desert-like areas of Sonora, in Alamos the tropical deciduous forest is a barrier to fire.

The disagreements between producers and environmentalists reflect fundamental differences in how nature is perceived and conservation is defined. Whereas environmentalists' concerns about the effects of deforestation on biodiversity warn of the gravity of the environmental situation in the municipio, they do not address land use and policy issues other than the need to ban forest clearing. Rather than recognizing the diversity of experience and knowledge of the local environment among producers, users are lumped together, and nature is perceived as in need of protection from those whose livelihoods depend on it. Resource users are characterized as ignorant and in need of being educated. Because their activities are generally portrayed as "inadequate" (CES 1993), conservation efforts by resource users and changes in management practices aimed at environmental protection have been undermined.

In contrast, producers perceive the physical environment as a place of work and buffelgrass as a positive factor because it has brought benefits to a region that has no other key economic activity. Environmentalists are perceived as outsiders with little appreciation for the intricately shaped political ecology of the municipio. For successful ranchers and ejidos situated in flat lands with coarse sandy soils, conversion to buffelgrass, followed by proper management, does not result in land degradation. Instead, cultivated pastures are considered an asset, and environmental protection refers to the careful management of productive areas. For ejidatarios and small landowners, planting a few hectares of buffelgrass, coupled with timely access to credit, may make the difference between going bankrupt or continuing to make a living from the land. Small buffelgrass pastures may have a beneficial environmental impact by reducing pressure on agostadero lands.

For the most marginal producers in the Sierra, environmental protection is a question of economic survival, not of enhancing quality of life. Deforestation has led to erosion and a loss of potential assets, diminishing their productive options. Concerns with resource overexploitation may be overshadowed by immediate economic needs. Environmentalists have generated resentment, especially among these most marginal producers. In the words of one ejidatario, "Ecologists are not seeing the whole picture, they don't understand what motivates people to exploit vara blanca. They protest too much without providing any alternative; they think that people work for sport. Well, let *them* support the people."

Conclusions

For Mexico, patterns and processes of land-use change are at the core of debates about the sustainability of rural livelihoods, the impacts of agricultural and environmental policy, and the causes and consequences of environmental change. We have endeavored to provide an empirically informed understanding of these processes and the linkages between them by examining one region of northwest Mexico where dramatic transformations have occurred since the 1970s.

Our research has been guided by a political ecology approach that places an emphasis on the complex interactions between the environment, political and economic policies, and land-use decisions. The drivers of environmental transformations that we identified were partly political-economic (i.e., modernization and land tenure policies), partly climatic (i.e., drought), and partly biophysical (i.e., edaphic conditions). We examined how these drivers interact through history and how they affect and are affected by the land use decisions made by a wide range of producers. Our objective in emphasizing a political ecology that focuses on interactions, rather than on prioritizing the political over the ecological, has been to achieve a more balanced understanding of the complexities of human-environment relationships in fragile ecosystems.

Paying attention to environmental parameters allowed us to dispel overgeneralized claims about, for example, buffelgrass expansion. As opposed to other more arid municipios in Sonora, specific biophysical characteristics of Alamos explain why buffelgrass has not spread uncontrollably, or why it has been only viable in certain regions and failed in sites that simply are not ecologically suitable.

We have also endorsed a political ecology approach that places an emphasis on understanding the heterogeneity of local environments and livelihoods. By doing this we have attempted to show the contradictions that result from trying to apply the "one size fits all" development schemes of the 1970s and 1980s, which were implemented without regard to the biophysical differentiation of the municipio (its topography, climate, soils, and vegetation). Decisions also were made without taking into account the heterogeneity of the municipio's rural inhabitants, their differential access to critical resources (credit, land), and differences in knowledge of important environmental parameters between the municipio's long-term rural residents and new investors. In the end, the environmental costs of these omissions further reinforced the marginal position of ejidatarios and small producers and largely contributed to environmental degradation.

Whereas in the past, issues of economic development took precedence in the management of the municipio's natural resources, today the evidence seems to point toward an increasing environmental awareness. Environmental policies, however, continue to ignore the experience of local producers and, rather than perceiving resource users as potential partners in conservation efforts, they attempt to reconstruct local

people's relationship to the environment. By doing this instead of solving environmental problems, today's environmentalism risks mantaining class-based inequalities and furthering tensions. Whereas in the past small producers who wanted to invest in buffelgrass pastures were considered entrepreneurial, today they are labeled as "inappropriate."

Among producers, definitions of environmental degradation differ because they are confronted by differential access to technologies, environments, and economic and political opportunities. In their land-use decisions, they respond differently to structural changes that occur at the global and national levels, as well as to environmental degradation at the local level. Their responses are not determined because it is clear that individuals are expressing agency in their decisions and discussions about land use in their communities. Today new land-management practices and diversification among specialized ranchers seem promising in their attempt to counteract some of the negative ecological impacts of rapid land conversion. Also, for the more marginal producers, the ability to plant and maintain a few hectares of buffelgrass may not only improve their economic situation, but also relieve excessive pressure on agostadero lands. In this case, there may be an opportunity for economic development through better resource management practices even on suboptimal land.

Finding practical solutions to the complex environmental problems faced by rural populations in Mexico and throughout Latin America requires an empirically informed understanding of how economic, environmental, and ideological differences interact at the local level and of how resource users adapt to complex political ecologies. Strategies for reducing deforestation rates and working toward sustainable development must consider the local and external causes of deforestation, the difficulty of environmental monitoring, and intraregional differences in both environmental and socioeconomic parameters. Only by understanding these interactions can we hope to develop and encourage reasonable, community-based medium and long-term plans that promote sustainable rural livelihoods.

Notes

[1]Pulido (1996) makes a distinction between mainstream environmentalism and subaltern environmental struggles. The former emanates from core countries and focuses on narrowly defined quality-of-life issues and the conservation of highly visible species and parts of nature. Subaltern environmentalism involves nonelitist groups concerned with questions of economic survival, equity, and resource distribution.

[2]Several problems were encountered with the census data. The 1990 agricultural census surveyed 20 percent less land area than the 1970 census. Also, the 1980 census was not used because it was never published in a complete disaggregated form. Data sets were analyzed for trends.

[3]State-level data indicated that, compared to agostadero lands, buffelgrass increased average carrying capacity from 33 to 3 hectares per animal unit (Martin 1997). Unpublished data for the Municipio of Alamos from the Secretaría de Agricultura y Desarrollo Rural indicates an increase in average carrying capacity from 20 hectares per animal unit in agostadero lands to 3 hectares per animal unit in buffelgrass pastures.

[4]In 1970 the municipio had the greatest amount of forest cover (132,702 hectares, or 27 percent of total area) in the state of Sonora; by 1990, forest cover had declined to only 5 percent of the municipio's total area (25,472 hectares). Alamos was the second highest municipality with respect to forest-cover loss in Sonora, a significant factor because within Mexico, Sonora experienced a greater than average loss of forests—nearly 71 percent loss compared with 56 percent loss nationally (INEGI 1990).

[5]Establishment of buffelgrass has been associated with changes in soil properties, mainly a decline in the organic carbon and nitrogen content that eventually leads to lower fertility (Ibarra-Flores et al. 1999).

[6]According to CES (1993), 51.5 percent of the land within the biosphere belongs to private owners, 39.1 percent corresponds to ejidatarios, 8.5 percent is classified as land without clear ownership status (some of this land has been invaded by landless peasants), and 0.9 percent is considered federal land.

[7]These observations are in agreement with Ibarra et al. (1995). After classifying seeding sites in Mexico, they conclude that established populations spread to unplanted sites at only a few locations. In most cases, plant populations persist but do not spread, or they disappear.

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