GLOBAL LAND USE CHANGE.
A PERSPECTIVE FROM THE COLUMBIAN ENCOUNTER

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CHAPTER 7

TRANSFER OF THE MEDITERRANEAN LIVESTOCK ECONOMY TO NEW SPAIN: ADAPTATION AND ECOLOGICAL CONSEQUENCES

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Introduction

The Columbian encounter had many short- and long-term consequences. But human and biotic ecosystems have complex feedback loops, so that the eventual outcome of any one "input" derived from this great, intercontinental exchange could not be predicted. Commonly, the relation of cause and effect took generations, if not centuries to understand. One of the most momentous and problematic features of this exchange was the deliberate transfer of Old World domesticated livestock to the Americas.

Due to a fortuitous set of Cenozoic evolutionary and biogeographical processes, the New World had few wild animals that, in terms of temperament, ecology and economics, were suitable for domestication. Whereas distinct trajectories of agricultural coevolution on both hemispheres produced different but equivalent repertoires of cultigens, the New World lacked a counterpart to domesticated cattle, sheep, goats, and pigs. These animals enriched the prospects and quality of life in the Old World with meat, milk, and fiber, while increasing crop productivity through their indispensable fertilizers. One such system of livestock-raising that has enjoyed great longevity was practiced in the Mediterranean world (González Bernáldez, this volume).

Yet despite its known viability, Mediterranean pastoralism has long been under attack, both as prejudicial to agriculture and as ecologically destructive. These two issues should be sharply distinguished, as they always were in the past. Cultivation and pastoralism in the Mediterranean world have always been combined, as a complex

subsistence strategy to (a) use different kinds of environmental resources in heterogeneous landscapes, and (b) minimize subsistence risk by providing animal foods that complemented cereals and were commonly susceptible to different climatic hazards. But herd animals require constant supervision in a mosaic of cultivated fields and upland pastures, and their propensity to forage on crops assures a constant tension, as a result of periodic and inevitable damages. Such tensions come to a head during times when agriculture expands, encroaching on traditional pastoral preserves, as was the case in Spain around 1450-1600 (Butzer, 1988a).

The standard historical study of long-distance sheep transhumance in Spain -the *mesta* - was unfortunately written by an American scholar with no agricultural background (Klein, 1920), who took a very narrow view of pastoralism, that has had inordinate influence. In dealing with Spanish pastoral activity in Colonial Mexico, Chevalier (1952, 1963) and Simpson (1952) failed to appreciate the built-in dialectic of agropastoral systems and used the substantial evidence for crop damages to Indians out of context, much as if modern crime statistics in America were grounds to assume total lawlessness and a lack of law-enforcement. More recently, a host of political ecologists have broadened the charge against Colonial pastoralism to assume that it was, by definition, environmentally destructive.

The introduction of a suite of domesticated animals to a new environment will inevitably reduce biodiversity and increase ecological fragility. As disturbing as that reality is, the subjugation and dispersal of selected biota by humankind can no longer be reversed. Two, more productive questions concerning the transfer of Spanish livestock to the Americas are:

(1) Did such introductions lead to acute environmental degradation, and if so, immediately (within a century) or with a notable lag (after several centuries), and at a local scale or over wide areas?

(2) Was the net impact for the indigenous population positive, negative, or disastrous, when weighing resource destruction, or infringement on arable land, versus benefits in regard to subsistence risk, nutrition, and fertilizer?

In order to reach even partial answers to such complex questions, archival research must be combined with field study of the biophysical evidence, to focus directly on land use and environmental history. One of the most detailed sources of potential information on Spanish pastoralism in early Colonial Mexico is provided by the land titles or *mercedes* preserved in the Archivo General de la Nación in Mexico City. Together with two "stray" volumes now in Chicago and Washington, these materials comprise some 25 000 folios, and include over 10 000 land grants from 1542 to 1643. These deeds,

when studied systematically -- rather than selectively or on the basis of the marginal indices -- serve to document both the processes and regional patterns of land acquisition, livestock management, and related problems. But they must also be evaluated in the context of the resolutions (*actas*) of the *cabildo* of Mexico City (Orozco y Berra, 1859) and the royal decrees (*cédulas*) of the period (Puga, 1563; Bentura, 1787; Dusenberry, 1963; Solano, 1991).

This paper is based on detailed study of some 6000 *mercedes* from selected areas of New Spain, and provides a first outline for the origins and evolution of the Spanish livestock economy in Colonial Mexico based on systematic and primary research. Comparisons with Iberian antecedents (Butzer, 1988a) are emphasized, and the implications of livestock for the Indian population and for the environment are examined. Finally, the expansion and regional developments of this increasingly autochthonous economy, to the frontiers of New Spain and beyond, are briefly sketched. An overview such as this cannot be accompanied by an appropriate, scholarly apparatus of documentary citation. Such supporting data must be deferred to a book-length presentation currently in preparation.

Evolution of the Livestock Economy 1526-1643

Precedents for the allocation of lands to new settlers in Mexico are provided by the Christian repopulation of the Iberian Peninsula during the Medieval Reconquista. Good documentation exists for the *repartimientos* of Valencia and Sevilla in the 1240s, when lands or incomes from lands were assigned by the kings of Aragón and Castilla to their political supporters and soldiers, according to rank and merit (González, 1951; Cabanes and Ferrer, 1979). This concept of *repartimiento*, as distinct from the later requisitioning of Indian labor in Hispaniola, was again applied, immediately before discovery of the New World, during the reconquest of the last Moorish kingdom in Granada (1486-92) (Ladero, 1968; López de Coca, 1977). In the resettlement of Granada, an important distinction becomes apparent, between personal awards or *mercedes* given by the king, and the allocation of vacant lands to new settlers, made at the local level. But the fundamental goal of both types of awards was to resettle abandoned or vacant land, not to displace existing inhabitants.

Another critical precedent was the principle of landholding in Mediterranean common law, as reflected in the Visigothic law code of the sixth century (King, 1972), and the several competing legal alternatives, such as the *Siete Partidas*, of the thirteenth century

(see López, 1555). The holding of land was ultimately based on usufruct, so that uncultivated or abandoned land (*tierra baldía*) could be assigned by the king. The *vecinos* of most municipalities had additional claims to communal lands, used to graze animals and collect firewood, while other tracts were under *señorial* jurisdiction (Gerbet, 1982; Vassberg, 1984). The remainder constituted public domain (*realengo*), open to grazing by all herds--although commonly at a fixed fee per head; unimpeded passage from one pasture zone to another was carefully safeguarded (Butzer 1988a, with references).

These institutions had profound implications in the New World, by opening up all uncultivated land to Spanish livestock. In particular, since the Indians did not initially own livestock, they lacked effective claim -- in Hispanic eyes -- to communal lands that were vital for the collecting of wild foods and fuel. Thus the 1533 *cédula* (Puga, 1563: f.85v) affirming commonage (*montes comunes*) guaranteed free access to woodlands, pastures and waters, but this was to stop Spanish infringements on the *ejidos* of Mexico City, not to express parallel privileges for the Indians. The first reference to Indian *ejidos* is from 1540 (see Orozco y Berra, 1859: III, 199).

The initial introduction of cattle and sheep to New Spain is linked to Cortés (Prem, 1992), but the *cabildo* of Mexico City first awarded licenses for sites -- *sitios* or *asientos* -- to keep sheep in 1526. Although most *mercedes* made by the *cabildos* of Mexico City (Orozco y Berra, 1859) or Puebla de los Angeles (Fernández de Echevarría, 1780) until 1537 were for small tracts of irrigated land, in keeping with the precedents set in Málaga and Granada, a handful of grants for sheep *sitios* were given out in most years. The uncertainty of the authorities can be seen from those grants of 1530 that were specified for grazing only, not for property rights. Yet a series of royal *cédulas* -- authorizing *cabildo* awards (in 1531), encouraging Spanish settlement and farming (1533), and legalizing *cabildo* grants of multi-use farm land (old-style *caballerías*) to conquistadors and qualified settlers (1535) (Puga, 1563: ff.37, 86, 108v) -- failed to evoke a systematic distribution of land.

Indian protests in regard to land usurpation or damage by animals to crops had begun promptly in 1524, but in regard to pigs (Orozco y Berra, 1859: I, 7, 79), and the indecision regarding land distribution may have been the result of intervention by the missionary orders on behalf of Indian rights, an instance of which is documented in 1533 (Orozco y Berra, 1859: III, 41). Part of the initial problem seems to have been the question of disregarded Indian claims to commonage. A second issue was that, in Spain, herds from elsewhere (*ajeno*) were allowed to graze on stubble (*rastrojo*), but by prior arrangement, in the harvested fields of a community, and only until the new crop

emerged. The Spaniards in Mexico insisted on this traditional right, at times too early in the harvest season (Sarabía, 1978: 269), and the Indians were incensed by such an incomprehensible privilege--as well as initially unaware of its benefits in terms of manure.

The interminable delay in formal land distribution -- from 1527 to 1542 -- had major repercussions because herd expansion, livestock dispersal, and management patterns developed spontaneously, rather than in response to official policy or control. This becomes evident from: (a) the formal organization of a stockman's association or *mesta* in Mexico City in April 1539 (but functioning informally since at least 1529), designed to deal with open-range cattle and sheep raising, with its attendant problems of ownership claims, theft, and damage to cropland (Orozco y Berra, 1859: II, 1; IV, 313-16); and (b) a *cédula* of November 1539 on the collection of episcopal tithes (*diezmos*) from herds that -- seasonally or in the short-term --moved regularly from one diocese to the other (Puga, 1563: f.119; Orozco y Berra, 1859: V, 27). These events demonstrate that a completely mobile, local or long-distance pattern of mobile stock management had emerged during the 1530s. Even formal sheepwalks (*cañadas*) are recorded as early as 1544 (Orozco y Berra, 1859: V, 63, 65). Great herds of cattle and sheep moved around what were seen as public lands, migrating from one region to another, following Castilian customary law.

After six years of prevarication, Viceroy Mendoza finally issued a flood of land titles in 1542-43, almost 1000 of which are preserved. These grants distinguished *sitios,* for large or small stock (almost exclusively cattle versus sheep), on which a nucleus of animal sheds and *corrales* had to be built within one to several years. No units of size are specified in the grants, but a critical document of July 19, 1538, now in a private archive in Mexico City (Escobar, 1984: 281, n. 23), specifies a tract of 3000 *pasos* square (1 *paso*=1.397 m) (1750 ha) for cattle and horses and 2000 *pasos* square (780 ha) for sheep, evidently the same measures for *sitios de ganado mayor* or *menor* formally specified after 1560. Nonetheless, the cumulative evidence shows that a *sitio*, a term gradually replaced by *estancia*, was nothing more than a seasonal headquarters for a particular (but mainly implicit) number of animals. By contrast, agricultural land was given out in units of standard size, specified as 115 by 230 *pasos* (5.2 ha) in 1537 (Orozco y Berra, 1859: IV, 72); this remained the practice until 1563.

In the meantime, the mobile livestock economy threatened to go out of control. Mendoza and his successor, Luís de Velasco (1550-64), not only had to cope with countless, routine infractions of the rules governing dry-season transhumance

(*agostadero*). They were also compelled to take decisive actions by a number of notorious incidents in Oaxaca and the Llanos de Ozumba (1540s), Tequizistlan (1543), Cuautitlan (1551), the valley of Toluca (1555-60), Tepeapulco (1555), Tlaxcala (1550-63), Aculman (1563), and especially the outrageous rape of Jilotepec by 300 African slave herders with up to 30 000 head of stock in 1551. Each of these gross infractions involved members of the *cabildo* as negligent owners, and the Jilotepec debacle included a list of 29 of the most powerful citizens of Mexico City, forcing the king in 1555 to appoint an independent adjudicator from Guatemala.

The viceroys, however, persevered in asserting the rule of law and, backed by the Council of the Indies, expelled cattle from Oaxaca, Jilotepec, and Tepeapulco for good, and brought the sheep barons of Puebla and Tlaxcala to heel (see Sarabía, 1978: 269-70, notes). Subsequently cattle raising was restricted to the tropical lowlands, the Chichimec frontier, and Toluca (Muñoz, 1592: 261-62; Torquemada, 1610: I, 610) -- where the cattlemen were eventually forced to pay for extensive protective fences covering areas of Indian cultivation. The existing literature fails to grasp that livestock transgressions were quite rare from 1563 to 1591, because the viceroys had indeed brought the system under control.

Before his death in 1564, Velasco modified land grant policy by enlarging the agricultural *caballería* to a unit of 400 by 800 *pasos* (42.8 ha), and explicitly defining *estancias* in measured units with prescribed stocking rates: 500 cattle or horses on 1750 ha, or 2000 sheep or goats on 780 ha.[1] Systematically appearing in the awards after 1563, these precisions were formalized by Viceroy Falcés in 1567. Instead of running three to five times that many head, and at large, the number of allowed animals was drastically reduced. Even so, mobility remained the practice. But estates could finally be delimited with boundary markers (*mojones*), as the public domain was systematically

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1. These stocking rates for cattle (28.5 head or 17 000 kg/km^2) versus sheep (256 head or 10,240 kg/km^2) give a biomass ratio of 1.7:1, that is in no relation to the ratios of relative body weight (600 to 40 kg, 15:1) or market value (5:1) of cattle and sheep. This suggests that stockmen were well aware that sheep, unlike cattle, crop grass down to its roots, creating a far more serious problem with overgrazing. But such biomass figures are very high, comparing with those for wild ungulates on lush, nutritive grasses in East Africa (10 000-20 000 kg/km^2) and exceeding those for the northern Great Plains during the buffalo era (3000 kg/km^2). To accommodate such seemingly impossible densities of livestock to the quality of browse and the modest, native grama grasses (*Bouteloua* sp.) of Central Mexico (A. Gómez-Pompa, pers. comm., 1989) -- which originally had an ungulate biomass of about 100 kg/km^2 (white-tailed deer and pronghorn) -- transhumance and other forms of mobile herding were indispensable. The estimate of biomass in Central Mexico is based on the number of ungulates taken during a traditional game-drive near San Juan del Rio in 1542 (Torquemada, 1610: 611-12).

converted into private property in most of central Mexico. Rapid settlement now becomes apparent in several regions, centered on areas of better land along the main *caminos reales*, as the process of land granting accelerated.

During the 1580s, reports and notarial records serve to detail the scope and scale of sheep transhumance: 200 000 head moving 250 km and more from Querétaro, westward to Lake Chapala and central Jalisco, accompanied by the sons of the owners and by a crew of Spanish *pastores*, who lived around that town as *transeuntes* during the rainy season (Butzer, 1989a). Even larger herds moved from Puebla into the lowlands of Veracruz, where the herd owners began to acquire formal land titles to winter pastures. By 1596, at least 750 000 sheep (and probably twice that many) annually streamed across the mountains from Jalapa to Orizaba, to winter on assigned *estancias* in the foothills or near the coast (Figure 1). In the Bajío, the situation remained more fluid. In 1588, *estancias para agostar* began to be requested around Lake Cuitzeo. Then, after 1597, relative peace on the northern frontier led to great treks of sheep northward, pasturing around Río Verde, later expanding into the more productive Huastec lowlands. A veritable land rush ensued in 1613-15 between Santiago de Valles and Tanchipa (Ciudad Mante), with a total of 140 winter sheep *estancias* awarded, and an additional 200 applied for beyond the limits of Spanish control. By the middle of the seventeenth century, at least 500 000 sheep wintered in these regions, up to 400 km from the Bajío.

Momentous changes were also taking place in agricultural settlement. About 1590, roughly a third of the cultivable land of the Basin of Mexico was occupied by Spaniards, and as the Indian population plummeted with the great plague of 1575, more and more Indian land was bought up, or claimed as deserted. Sheep *estancias* were awarded on the rougher piedmont slopes, for animals that were wintered on the warm plains of Morelos. Much the same happened on the other side of Popocatepetl, along the foothills of Huejotzingo (Prem, 1992). By 1615, although the *chinampas* around Lake Xochimilco remained in Indian hands, Spanish ownership had been imposed on the irrigated Indian *huertas* of Tlalnepantla, Cuautitlan, and Texcoco (Figure 2), as well as on other such tracts from Jilotepec to Jalapa. In the Bajío, on the other hand, the Spaniards found several almost empty areas -- beyond the limits of traditional Indian agriculture -- for new, Spanish irrigation development. These included San Miguel after 1555, Celaya after 1563 (Murphy, 1986), Salvatierra after 1583, and Salamanca after 1608 (Urquiola, 1990). Here Spanish canal systems, field patterns, and water rules were implemented, in contrast to the Basin of Mexico, where little more than Spanish ownership was superimposed on existing systems.

By 1630, the rural economy of Central Mexico had been transformed. Spanish wheat farmers with unirrigated land either converted to maize or abandoned their grants, since wheat suffered serious blight problems when grown in summer (Murphy, 1986), while rainfall was insufficient for winter wheat. Others requested permission to shift to goats or sheep in order to provide milk, cheese and butter for urban markets. Holders of some sheep *estancias* applied for permission to introduce dairy cows. A process of intensification is evident, as the pastoral economy appeared increasingly inappropriate in an urban hinterland. In the eastern Bajío, some 200 000 cattle in about 1580 had been reduced to 45 000 by 1630 (see López Lara, 1973), as the rural sector focused on production of wheat and maize, with sheep raising increasingly limited to the rougher uplands. By 1600, the large estates had coalesced, and there was no more land available for the continuing flow of Spanish immigrants to the eastern Bajío that began about 1590 and only ended about 1640 (Super, 1983; Butzer, 1989a; Urquiola, 1989: 29-197; Barroni, 1990). Such new settlers were forced into urban occupations or to work on large estates, where they began to assume leaseholds on small plots. The western Bajío, by contrast, was still in the process of development; here, extensive cattle grazing continued, with 140 000 head verified in 1630 (see López Lara, 1973).

The marginalization of sheep raising was accelerated after 1633, when the first 800 km transhumance trek reached Nuevo León (Chevalier, 1952), a frontier area sparsely settled by new Spanish colonists in 1626. Its governor offered vast grants to the *agostaderos*, and the number of sheep from Central Mexico on its winter pastures swelled from 300 000 in 1648 to a million in 1715 (Cavazos, 1961; Hoyo, 1972). The scale of operation and holdings by the sheep barons who dominated this massive transhumance is illustrated by the last will of Don Juan Caballero y Ocío of Querétaro in 1689 (Rincón Frías, 1984). He left 195 000 sheep and 271 *sitios de agostadero*, including 17 in San Miguel, 57 north of San Luís Potosí, 113 in the Huasteca, and 84 in Nuevo León, with a work force that comprised 140 African slaves.

Patterns of Spanish Land Use during the Early Seventeenth Century

In New Spain proper (here termed Nueva España), the process of land granting came to a close in 1643, as the majority of the holders of deeds paid a relatively small sum in order to secure permanent title (*composición*). Although grants continued to be awarded by local authorities in Nueva Galicia, Nueva Vizcaya, and Nuevo León the later *mercedes* of Nueva España consist mainly of licenses, adjustments, and transfers of property, with only a trickle of new land grants. It is still not possible to delineate the

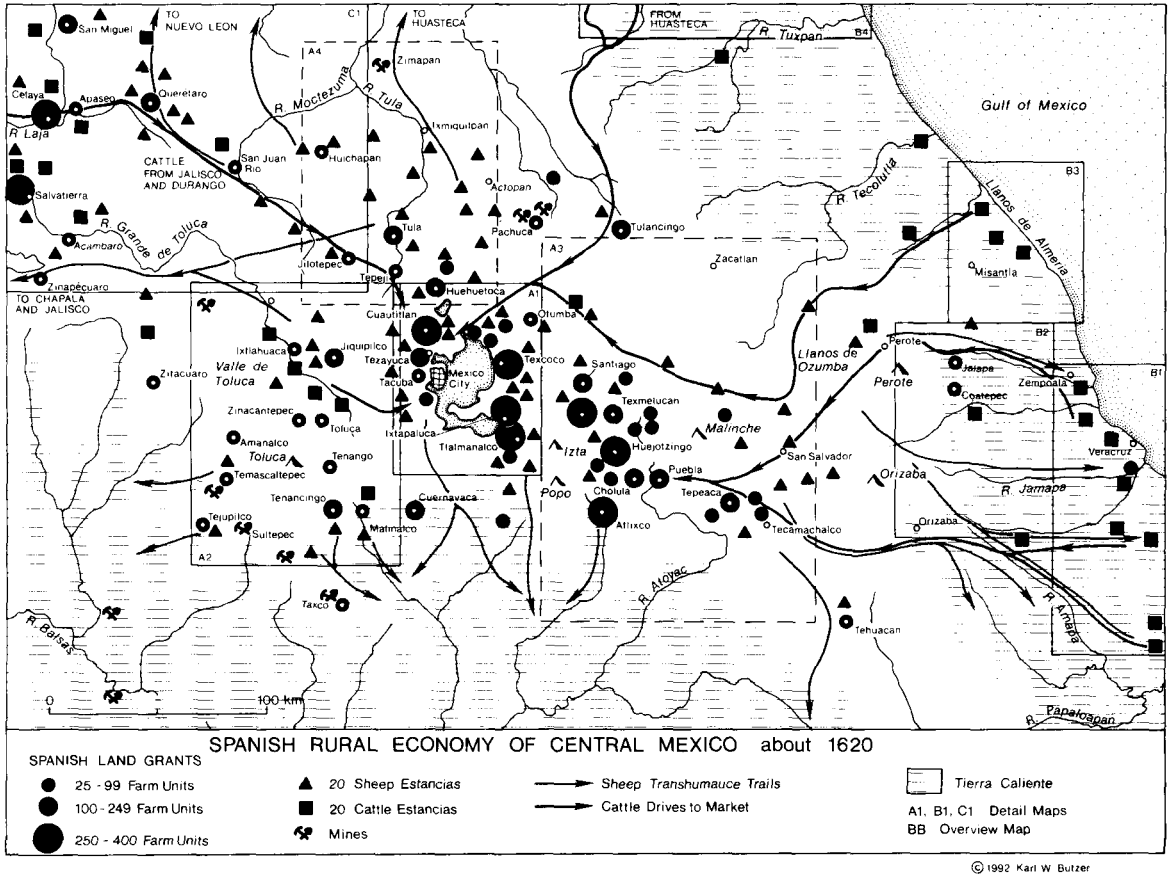

Figure 1. The Spanish rural economy of Central Mexico about 1620, as based on land-grant records and other documentary evidence. The complete frames indicate areas for which semidetailed mapping has been completed; the dashed frames are areas in which preliminary analysis has been initiated, in part based on other studies.

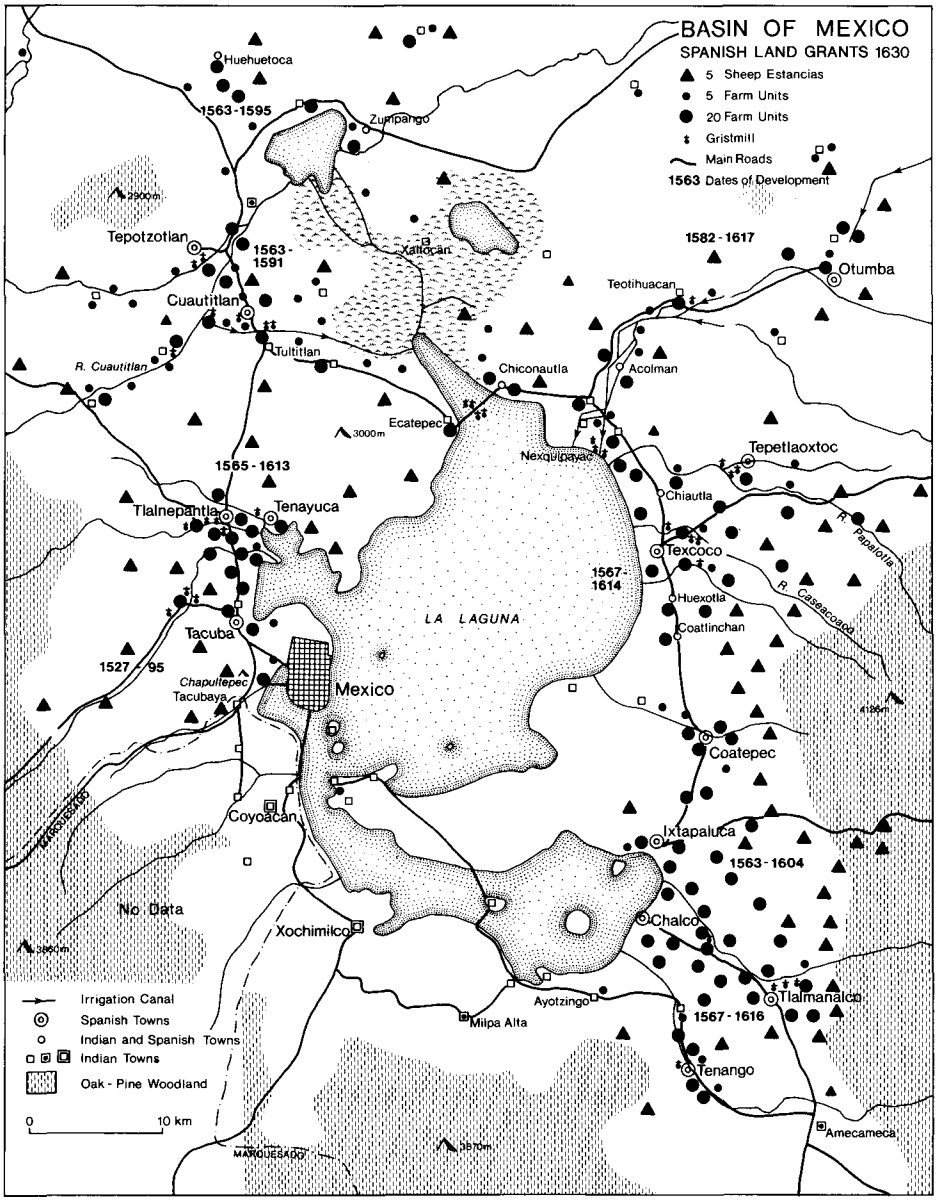

Figure 2. Patterns of Spanish land grants in the Basin of Mexico by 1630 (see A 1, Figure 1). No data are available for the area southwest of Mexico City, controlled by the Cortés family and known as the Marquesado, since any land titles here would be in another archival repository. The absence of awards to Spaniards around Xochimilco is, however, significant and indicates that this region was off-limits. The location of sheep *estancias* near the edge of the forest is very approximate since such titles provide few useful landmarks.

picture of cumulative Spanish landholdings in Nueva España as of about 1640, but a partial overview can be offered for most of central and eastern Nueva España (Table 1; Figures 1-3).

(a) In the rural economy of the heartland of the colony, centered between Mexico City and Puebla (Figure 1), Spaniards held some 1500 km^2 of agricultural land, almost 40% of the total of this quality awarded in New Spain. When the less nucleated but contiguous areas of Toluca, Tula, and Cuernavaca are included, this central nucleus accounts for 58% of the agricultural land. Most of the remainder (20%) was concentrated in the secondary heartland of the eastern Bajío.

(b) Most "home-base" sheep *estancias* were also found on the plateau, between San Salvador de los Llanos and San Miguel (Figures 1 and 2), around the fringes of the agricultural grants, mainly on rougher lands. This belt accounts for some 80% of perhaps 2000 home-base grants. Roughly another 1000 sheep *estancia* titles within Nueva España, and many more beyond the northern border, were *agostaderos* for dry-season grazing. Nominally, 2000 *estancias* represent about 4 million sheep, although the true number may well have been in the order of 6 to 8 million or more. As a result of the well developed transhumance patterns, these animals ranged through a territory of some 500 000 km^2. Figure 1 shows the major axes of long-distance transhumance: towards the lake basins of Chapala and Jalisco; Nuevo León; and the piedmont below Jalapa and Orizaba. Based on less substantial evidence are the short-distance transhumance routes suggested in Figure 1 from Puebla, the Basin of Mexico, and Toluca south into the adjacent foothills within the *tierra caliente*, the tropical ecozone that provided fresh pasturage at the onset of the cooler and drier part of the year.

(c) Cattle *estancias* are conspicuously absent in the Mexico City-Puebla area, although there was a small cluster in the Valle de Toluca. The major concentration of such grants was along the Gulf Coastal Lowlands (Figure 3). Whereas the Gulf cattle *estancias* continued to be active in 1640, the second cluster, in the Bajío, had demonstrably declined, with fewer cattle verified in 1630 than would have theoretically been allowed. We tentatively estimate 400 000 cattle in the Gulf Lowlands, 200 000 around Toluca, 200 000 in the Bajío, and perhaps 150 000 in both Michoacan-Jalisco and the Pacific Lowlands. Altogether this represents 1.1 million cattle, although that number may well have been as high as 1.5 to 2 million. It is possible that these animals

Table 1. Lands Granted to Spaniards in Central and Eastern Mexico, 1526-1643

Region	Agricultural Units	Sheep Estancias	Cattle Estancias	Horse Estancias	Grist-mills	Total Land Units
Basin of Mexico[1]	2112	416	---	2	32	2562
Puebla (incomplete)[2]	1534	255	19	3	7	1818
Gulf Lowlands (without Guazacualco)	391	593	733	144	5	1866
Valle de Toluca[1]	798	190	96	5	12	1101
Valle de Tula (approximate)[3]	700	400	6	---	5	1111
Bajío (to 1591 only)	966	333	407	4	47	1757
Provisional Totals	6501	2187	1261	158	108	10 215
Square kms	2782	17 059	22 143	2774	---	44 758

[1] In part, after Colín (1967).

[2] In part, after Prem (1978, 1984) and Licate (1981).

[3] In part, after Melville (1983).

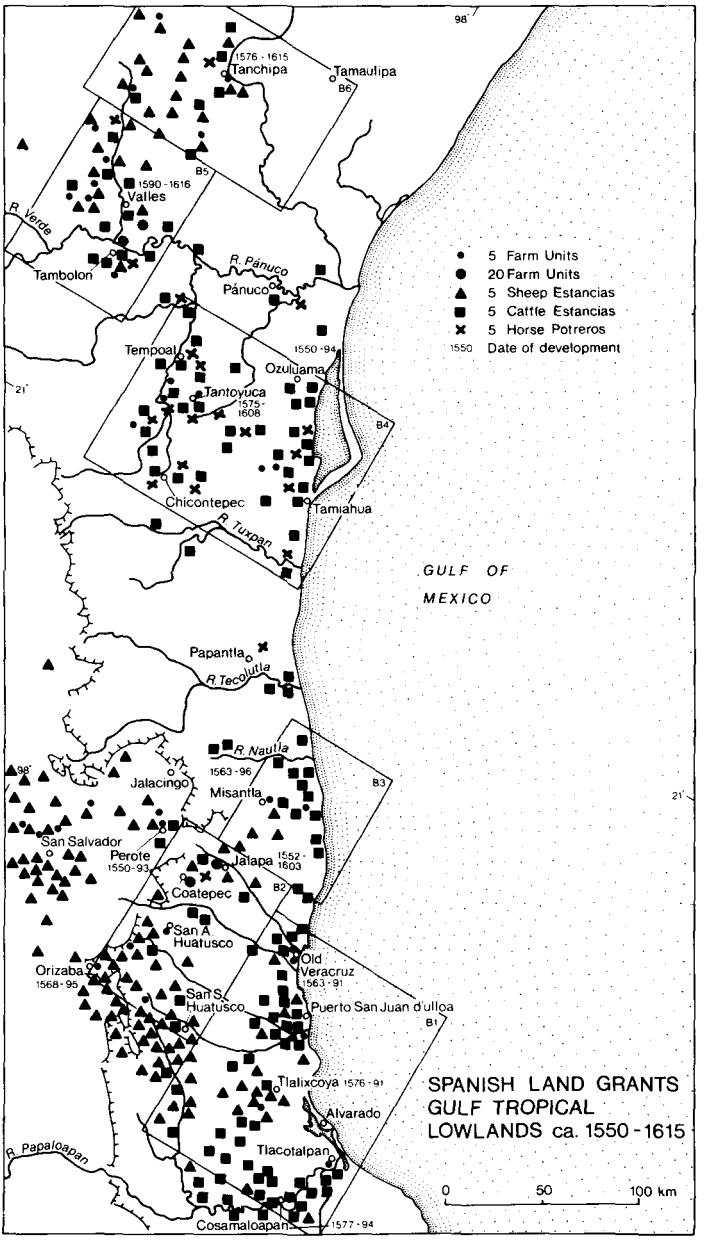

Figure 3. Overview map of Spanish land grants in the Gulf Tropical Lowlands, as awarded about 1550-1615 (see B 1 to B4, Figure 1). The different clusters were opened up for Spanish acquisition at various times, and only after these districts were almost totally depopulated as a result of epidemic disease. Indian settlement and land use continued without interruption in the "blank" areas of the map.

also ranged through an immense, thinly populated area of as much as 150 000 km^2, with a stocking rate as low as one head per hectare.

It should not be assumed, however, that feral cattle could multiply indefinitely in the *tierra caliente*. For one, there were effective feline predators for calves, and various parasites, especially along the Pacific littoral, that substantially undermined bovine health (see Acuña, 1987: 459). More important, perhaps, is that mature tropical dry forest (*selva baja*) provided very poor browse and only on a seasonal basis. Alternative, grassland settings were limited to the Gulf Lowlands, but these were dominated by coarse, tall grasses that became unpalatable and only minimally nutritional without fire management (Paso, 1905c: 195). Figure 1 identifies the important centers of cattle-raising that emerged in the Gulf Coastal Lowlands. It also shows the key, documented trails used to drive cattle from distant breeding pastures in the Gulf Lowlands or Nueva Galicia to the great urban meat markets of Mexico City and Puebla.

(d) *Estancias* for horse and mule breeding (*potreros para yeguas*) were found mainly (over 60%) in the tropical Huasteca. About 200 such titles suggest a minimum of 100 000 equines on such stud farms, although a figure of 150 000 is more probable.

According to our tallies, over 10 000 *mercedes* were awarded up to 1643, totalling perhaps 17 000 units of land. Table 1 details 10 000 such units, representing almost 45 000 km^2. Extrapolating to the remaining areas, we estimate that 23% of the 250 000 km^2 of what are now the seven states of Veracruz, San Luís Potosí, Guanajuato, Querétaro, Hidalgo, Mexico State, and Puebla had been formally awarded to Spaniards. With considerably less confidence, we further estimate that some 15% of the 500 000 km^2 territory of Nueva España had been legally converted into Spanish holdings. Considering that the records are incomplete and that many properties were initially acquired without proper titles, these values were probably closer to 40% and 25% in reality.

The larger picture of Spanish land grants in Nueva España suggested by Figure 4 shows that they were notably clustered around an axis extending from Veracruz to Mexico City, Zacatecas, and beyond. Many of the remaining areas were forested mountains or less attractive tropical lowlands. But other sectors with few land grants remained populated by relatively intact Indian groups: the Tarascan heartland of Michoacan, the Mixtec and Zapotec regions of Oaxaca, or the great mosaic of Totonac, Nahua, Otomí, and Huastec landscapes between Jalapa and Valles, to mention major

regions with minimal Spanish intrusion. The *mercedes* are unambiguous for the woodland environments of the Sierra Madre Oriental, where Spanish *estancieros* were systematically expelled by the viceroy. On a more detailed scale, it is apparent that land was only opened up for settlement when the Indian population had dwindled away, to the point that residual populations of less than a dozen or so families were moved to larger nuclei (*congregaciones*). Thus a substantial part of the unawarded land was deliberately reserved as *patrimonio primitivo* (traditional Indian lands). We hazard a guess that some 45% of Nueva España remained *patrimonio*, in the viceregal vision of things. That leaves perhaps 30% non-agricultural domain or *tierras baldías*, mainly forested mountains or semidesert, thinly settled by more mobile Indian groups.

A semiquantitative estimate for Spanish land allocations and livestock raising in Nueva España is presented in Table 2, as representative for the period about 1620-50. We emphasize that this is an estimate, since our completed documentation covers only 40% of this area, but almost 60% of the titles awarded. In depicting this information as a map (Figure 4), we move into a more impressionistic arena, particularly for the southern and western parts of Nueva España, and for the delimitation of the *patrimonio primitivo*. This cartographic assay is nonetheless based on a substantial body of hard data, leading us to conclude that the map of Chevalier (1952, 1963) is unreliable.

In order to provide a broader picture for preliminary comparison, Figure 4 has been extended to include Nueva Galicia, Nueva Vizcaya, and Nuevo León, based on the district compilations of Gerhard (1982), as well as on a variety of sixteenth to seventeenth century primary reports, and a first inspection of the Monterrey Municipal (Ramo Civil) records (see also Cavazos, 1961). For these areas the map represents no more than a second approximation, rendered particularly difficult by the widespread conversion of cattle *estancias* to sheep pastures in Nueva Galicia during the 1600s. Bounded by vast *tierras baldías*, Spanish livestock will also have grazed far beyond the limits shown, which demarcate areas with seventeenth century *estancias*.

The Indians and the Spanish Livestock Economy

Whatever its flaws in detail, Figure 4 gives a representative overview of the patterns of dominant land use and land allocation among Indians and Spaniards by the mid-1600s.

These patterns can be examined at different scales, with different levels of resolution.

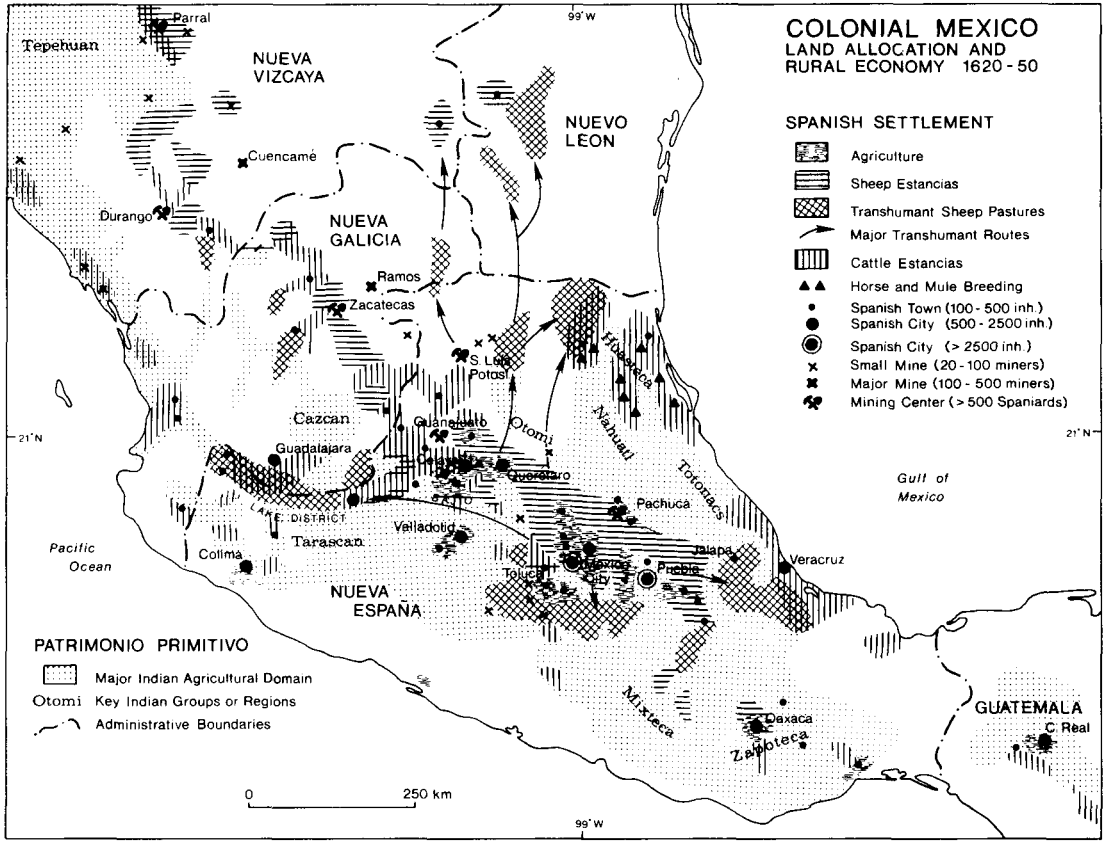

Figure 4. Land allocation and rural economy in Colonial Mexico, about 1620-50. The boundaries for agricultural areas and pasture zones are impressionistic, and the data base for Nueva Galicia and Nueva Vizcaya is minimal. The several regions of relatively undisturbed Indian agriculture are significant, and the channelling of Spanish economic activities reflected both policy and choice.

(a) At the macro-scale it is striking that vast areas of traditional Indian agricultural settlement in Nueva España remained almost undisturbed by direct Spanish intrusion. With the demise of the *encomienda* system and its labor demands, these areas were reorganized and dominated by the missionary orders, to be converted into a kind of theocracy.

(b) A substantial part of Spanish settlement spread beyond the margins of agricultural settlement, which in 1519 lay south of the Bajío. Almost all settlement expansion after 1700 was directed to the *tierras baldías* of the north.

(c) Most of the concentrated Spanish settlement in Central Mexico coincided with the core of the former Aztec state, although there was encroachment on the lands of Spain's Tlaxcalan and Otomí allies.

At a smaller scale the documentary record shows unambiguously that, at least at the level of viceregal policy, Indian farmland was not to be dispossessed. Despite the pressures to create a hinterland of wheat-producing farms in the Basin of Mexico, less than 15% of the land titles eventually granted here had been awarded before the mid-1560s. Even in 1640, only 75% of that region had been legally allocated to Spaniards, although the true figure was certainly higher. Although the absence of preserved land grants during 1545-49, 1557-59, and 1569-72 is commonly interpreted as a matter of lost record books (e.g. Simpson, 1952; Prem, 1992; Melville, 1983), these years also coincided with demonstrable shifts in viceregal policies (see Hanke, 1976-77; Sarabía, 1978), made in response to spates of livestock infringements on Indian lands, during the tenure of Mendoza and Velasco, and in the last case reflect the deliberate caution of Viceroy Martín Enríquez (1568-80), during his first five years of office. So, for example, Mendoza during 1544-47 was preoccupied with seeing to it that cattle *estancias* in Oaxaca and the Llanos de Ozumba were sold and converted to sheep raising, because of the flagrant damages caused by uncontrolled cattle herds. Velasco faced more universal problems and, after receiving several, increasingly impatient, royal *cédulas*, 1555-56, simply stopped granting land until matters were again under control. How successful he was can be judged by the fact that around 1580 the only cattle left in Puebla state were a few wild herds, hiding in the forests of Malinche and Popocatepetl (*relaciones* for Tlaxcala and Tetela del Volcán, see Acuña, 1984: 72, 1986: 269).

The grants were indeed issued in "waves", until the 1630s, reflecting fluctuations in policy, and the flood of titles awarded between December 1560 and early 1568 must be interpreted in such a fashion.

The conditional clause attached to each title, that the award not be prejudicial to the Indians or other third parties, were not mere formalities. Before a title was actually granted, the prospective owner was required to submit a petition describing the land parcel desired. This prospective area had to be visited by the royal magistrate of the nearest town, and if not in evident conflict, the request was proclaimed at the local church before Sunday services. Only if there was no protest was the award actually made, typically a year or two later. Land could not be awarded if already cultivated, or if within 500 *varas* (yards, later 700) of the outermost house of an Indian settlement. This did not protect Indian commonage, but if the impact of introduced herds was indeed deleterious, months later the matter did come up for renewed adjudication, and not infrequently the title was declared void. In some outlying areas, the Indians were probably cowed by local magnates and did not protest a potential award, as advertised; but the fact is that fully a third of the petitions made for land, especially in the years 1590-1620, were never granted. In general, therefore, the policy did work, despite innumerable cases of fraud, intimidation, or illegal "purchases" for ridiculously low prices (see Prem, 1978, 1992).

The acceleration of land granting in the Indian heartland after 1560, and especially after 1590, primarily reflected the Indian demographic collapse. As populations declined, especially after the epidemics of 1545 and 1575 (Prem, 1991), traditional cultivated lands were increasingly abandoned, and many grants were explicitly made for such *tierras eriazas*. Eventually, communities that had almost disappeared were consolidated in new locations by the missionary orders. Villages were also abandoned for various reasons, but primarily to escape *encomienda* work demands. The lands of an abandoned community would then be "opened up" for a spate of new titles and new settlers. But the viceroys were very clear about reserving agricultural land for agriculture, and abandoned farm lands were never awarded to stockraisers.

Some clusters or regions of Indian settlement remained viable, while others did not. As a result, outside of the Basin of Mexico, the Spanish land grants are noticeably clustered, with large areas devoid of grants between several such nuclei in the Valle de Toluca, southeast of Puebla, or along the Gulf Coastal Plain (Figure 3). In some cases, those areas without grants still show strikingly different field and land use patterns today, for example in the Huasteca. Such cases bear testimony to the basic efficacy and sincerity of viceregal policy during the sixteenth century.

Given the hundreds of recorded appeals to the viceroy to redress livestock damages to Indian lands, the question remains whether -- as already alleged by contemporary Spanish writers such as Zorita (1585: 269-71) and Torquemada (1610) -- village depopulation or abandonment was indeed caused by a lack of government intervention,

to stop persistent grazing and trampling of standing Indian crops. The record of such appeals that reached the viceroy's office is primarily preserved in the *ramos mercedes* and *indios*. The language generally follows a formula, that without redress a particular village will be abandoned. It is important to recognize that livestock depredations are inevitable with open-range grazing, and that the *mesta* organization in Mexico, as its counterparts in Spain (Marín, 1987) or Italy (Marino, 1988), was designed to adjudicate, and where necessary, arrange for payments against damages (Dusenberry, 1963; Bentura, 1787). Only those cases that were not satisfactorily resolved came to the higher court of the Audiencia. If that court decided in favor of the Indians, the stockowner was severely fined, beyond the damages that had to be paid through the offices of the *mesta*. Some such claims were spurious, and even Velasco, who was a stickler in regard to Indian rights, is on record that it was not uncommon for Indian villagers in some areas to deliberately plant new fields in designated grazing areas in order to collect damages. But litigation was expensive and often took years, facts which inevitably worked against the Indians.

An examination of Indian claims for damages to the Audiencia shows striking temporal and spatial patterns. A wave of Indian complaints followed the spate of land grants in 1542-43 and again 1550-56. These were indeed adjudicated, and resulted in years of land-granting freezes. That the stockowners were effectively disciplined by Velasco can be gauged by the paucity of Indian complaints following some 1500 awards during 1561-67. Problems only resurfaced in 1590, under Luís de Velasco the Younger, who issued almost 2200 grants during his five years in office. The younger Velasco, himself a major livestock owner, evidently was an ardent advocate of settlement expansion, and titles no longer included the explicit condition of not being prejudicial to Indian rights. But even if we allow that Indian protests had become subdued, it is striking that the great majority of such appeals to the high court came from a very few outlying areas, such as Michoacan, probably reflecting the disinterest of local or regional authorities in resolving cases that favored the Indians.

We do not contend that open-range grazing was without negative consequences for Indian livelihood, settlement continuity, or demography. But government policy in the matter was benign and basically effective, and damages were contained. This is an important point to which we will return in discussing land-cover change. Indian demographic decline was overwhelmingly due to epidemic disease (Whitmore, 1991; Prem, 1991), and it was that decline which made possible the expansion of Spanish livestock and agricultural activity, not vice versa. Spanish colonial administration, once

established, was one of rule by law, by laws that applied relatively consistently to all peoples. In this, Spain was centuries ahead of Britain, France, or Portugal, or for that matter, the European colonial powers in Africa around 1900, not to mention the United States during the nineteenth century.

In focusing on the negative impacts of introduced European livestock on the aboriginal populations of the New World, it is easy to overlook the potential benefits. Since the beginnings of agriculture in the Mediterranean Basin, agriculture and livestock have been complementary strategies that reduce subsistence risk (Butzer, 1988b). Climatological anomalies that impair productivity for one of these components commonly do not affect the other, and adult goats, for example, were only slaughtered during years of harvest failure or extreme scarcity.

In the Americas, the first and most enthusiastic adoption by the Indians of domesticated stock was of Old World chickens, which were hardier and more productive than indigenous poultry. In South America, pigs and sheep were also adopted early, particularly in the Andes (Gade, 1992), where the indigenous population had the requisite experience in dealing with domesticated llamas. By 1600 cured hams and cheeses were produced by Indians of Ecuador and Peru on a large scale for commercial purposes (Vázquez de Espinosa, 1629), providing a source of cash income or for tribute payment. More importantly, perhaps, sheep provided an opportunity to utilize high-mountain pastures that were too cold for cultivation, in order to produce meat, milk and its by-products, as well as wool. Pigs, on the other hand, could process domestic garbage in settlement areas, to provide a regular source of meat for home consumption. Without any doubt, these were significant benefits.

In Mexico, the transfer is more ambiguous. Many of the *relaciones geográficas* of about 1580 do not mention pigs, sheep, or goats as standard livestock kept by Indians, suggesting a delayed transfer that might be attributed to Mesoamerican lack of experience with larger domesticated animals. However, ordinances by the *cabildo* of Mexico City in 1526 repeatedly interdicted bringing pigs into town to sell at market or to raise in the city; since only one of three such zoning laws mentions a monetary fine (see Orozco y Berra, 1859: I, 72, 106, 108), Indians evidently were among the offenders. Viceroy Mendoza urged the Indians to run livestock (Torquemada, 1610: I, 611), and already in 1544 Indians were ordered to pay tithes on their livestock (Puga, 1563: f. 149). Encouragement to keep all kinds of livestock were reaffirmed in 1550 and 1551 (Solano, 1991: Nos. 56, 59). By 1560 some Indian communities or dignitaries were receiving licenses to run flocks of 12 000 to 28 000 sheep (Simpson, 1952: 14), and Muñoz Camargo, the indigenous chronicler of Tlaxcala, tells us (about 1579; see Acuña, 1984:

88) that in ten years his own herd of merino sheep had expanded from two animals to 10 000. In Nopaluca, Indian sheep owners eventually came into competition with their Spanish counterparts, requiring annual visits by officials of the *mesta* in the 1570s. Although Indians acquired land titles to many sheep *estancias* in some areas (Llanos de Ozumba, Valle de Tula, Mixteca), this does not seem to have been a prerequisite to them keeping substantial numbers of small stock. Although Indians rarely kept cattle, Ciudad Real (1591: I, 57) implies that most Indian towns had busy, illegal slaughterhouses for "stray" cattle, providing cheap beef.

In effect, the *relaciones geográficas* appear to have misrepresented the wholehearted acceptance of Mediterranean livestock by the indigenous population, perhaps because their management techniques were informal and, in most regions, implemented on a domestic scale. Quite apart from the reduction of subsistence risk, the nutritional impact of abundant meat for societies probably suffering from protein shortage in pre-Conquest times must have been highly significant for the Indians of New Spain.

There also were other important benefits. The Spaniards introduced the first transport animals to Mexico. Previously all heavy land cargo had to be carried on human backs, a practice gradually made unnecessary as the Spaniards built a network of wagon roads for mule trains. Eventually *burros* became cheap enough for Indians to buy and breed, greatly reducing labor requirements. In a similar vein, the rapid dispersal of the domesticated horse among the Plains Indians of the North America beyond Mexico after 1720 is credited with the rapid florescence of the Plains Hunting Cultures, that ended with the demise of the buffalo after 1865, as a consequence of American or American-sponsored overkill.

Last, but not least, domesticated livestock provide large quantities of manure, vital to replenishing soil fertility on a much larger scale than any available prehispanic technique (see Rojas, 1988). In the Mediterranean world, grazing on stubble is very much a reciprocal arrangement, welcomed by the traditional farmer as an indispensible means to maintain crop productivity. The impact of animal manure on indigenous fields, beyond the kitchen garden, must have been enormous in terms of increased crop yields, certainly compensating for episodic crop losses to uncontrolled herds.

In evaluating the overall impact of the introduction of Mediterranean livestock to the New World upon indigenous lifeways and quality of life, there evidently were serious problems in regard to competition for land, but the clear benefits for reduced subsistence risk, improved nutrition, and greater crop yields (see Rincón Mautner, 1988) must have outweighed the drawbacks.

Environmental Impacts of the Livestock Economy

The theme of ecological change or destruction by Mediterranean livestock is one that continues to be argued more as a matter of principle than in the arena of empirical evidence. Two different assumptions are commonly invoked in such presentations, both ultimately shaped by ethnocentric preconceptions.

(1) *An old and deep-seated bias by North European scholars and travellers against Mediterranean pastoralism*. Since the eighteenth century Enlightenment, visitors from France, Germany, Britain, and the United States noticed that the topography of the Mediterranean lands is more angular; that soils are thinner and of different color; that woodlands are few, open, and have low canopies; and that smaller streams almost disappear during the dry season. Unable to understand that the Mediterranean world represented a different environment, with a different earth history, they tended to assume that this was an impoverished landscape. Later archaeologists would assume that all monumental ruins in the Aegean world or North Africa had once graced a green, garden landscape reminiscent of a Berkshire estate, but that nomads had subsequently plundered the land of its natural richness, so much so as to change climate for the worse. Next came the Colonial or Unesco agricultural specialists, who identified sheep and especially goats as an environmental curse, and their efforts to eliminate pastoralism have recently been emulated by regional government agencies.

Today the animals are gone, and the open woodlands are suffocating in an undergrowth of thorny *matorral,* waiting to explode in periodic fires that destroy more timber than any army of voracious goats ever did. Pollen evidence shows that after distinctive, Neolithic to early Bronze Age experimentation, the Mediterranean woodlands have been more or less continuously managed as an artificial ecosystem that, on the whole, was sustainable (Harrison, 1985; Butzer and Martí, 1991; Boyazoglu and Flamant, 1992; González-Bernáldez, this volume). Cumulative damage to the soil mantle was no greater than in northern Europe, as studies of alluvial sediments show. But the pastoral sector of the economy continued to reduce subsistence risk, while providing the fertilizer critical to sustained crop productivity (Halstead, 1987). The acute risk to the Mediterranean ecosystem today has nothing to do with Bronze Age goats or Medieval sheep. It is first and foremost a matter of water contamination by industry and sewage. Livestock can indeed be very destructive to the environment, when poorly managed. But the mounting biophysical evidence shows that, historically, equilibrium management was the rule, rather than the exception. Over 200 generations of sedentary peoples were thereby sustained, quite successfully.

(2) *The implicit or explicit premise that the precolumbian Americas were ecologically pristine, and that introduction of the European agrosystem drove New World ecosystems to disequilibrium.* For centuries it has been assumed that, prior to 1492, New World populations were small and lacked the technology to significantly transform their environments. Recently, some militant ecologists and Native American activists have refashioned the Renaissance myth of an American Eden, to claim that New World peoples lived in harmony with nature, deliberately refraining from altering their environments, and that they somehow succeeded in maintaining an idyllic ecological equilibrium (e.g. Sale, 1990). Europeans, by contrast, had a ruthless land ethic, were driven only by materialistic goals, and introduced an agrosystem that was, by definition, harmful. The result was environmental destruction of apocalyptic proportions.

This picture is simplistic and flies in the face of two generations of research that has verified teeming populations in some parts of the New World (Denevan, 1992) -- real people whose nutritional requirements demanded that priority be placed on survival, rather than an abstract ideal of ecological integrity.

All forms of subsistence technology change land cover and *potentially* can degrade the environment, both New and Old World. The technologies introduced by Columbus or the Pilgrims were potentially destructive or wasteful, but they were puny compared with those of the Industrial Era. When and where and to what degree such new technologies fundamentally altered, let alone destroyed the environment of the New World must be determined empirically. Did such alteration attain regional significance in the first century after settlement, or only during the nineteenth century, with the aid of far more powerful, industrial technologies? Finally, is there a statute of limitations for blaming everything on "Europeans"? Livestock, for example, were introduced 500 years ago and, in the meanwhile, many different adaptive strategies for their use have long been developed, in the New World, by peoples who by any criteria deserve, let alone claim to be indigenous. As much as we lament the tone of the Columbian polemic, we are enthusiastic about the impetus it will surely provide for a new generation of active research on the environmental history of the Colonial Americas. Much has been done during the last decade, but it tends to be isolated, sometimes incidental, and commonly is published, if at all, in relatively obscure media.

Large parts of central and southern Mexico had been converted to agricultural landscapes before the arrival of the Spaniards (Whitmore and Turner, 1992). Archaeological evidence further verifies long periods of fairly dense settlement during the middle of the first millennium A.D. ("Classic") in several areas, as well as a few earlier

nodes of agricultural activity dating back a millennium further ("Formative"). Various lines of paleoecological work confirm this, verifying land-cover change, at times quite substantial, back to at least 3000 B.P. The question then is whether Spanish land use was qualitatively and quantitatively different than that of the prehispanic occupants, possibly expanding or intensifying land-cover changes.

Both qualitative arguments and semiquantitative estimates can be offered that the aggregate area of land use in Nueva España *decreased* substantially after 1519, despite Spanish colonization efforts and land acquisition. This was entirely a result of Indian population decline, the full implications of which for land abandonment -- and changes in land cover --have to be considered:

(a) Archaeological and paleoecological evidence (as discussed further below) is consonant with the high population estimates extrapolated back to 1519 on the basis of Spanish records of the mid- to late 1500s. These estimates vary from about 10 to 25 million, depending on the author and the assumptions used, for the area here defined as Nueva España (Figure 4). We favor the lower end of this range, which approximates that of the region in 1910, after initial industrialization and completion of the railroad network. That would compare with a total population of perhaps 1.5 million around 1620-50, when the indigenous population was at its nadir and Spanish and mixed-race numbers still were small (about 200 000) (see Cook and Borah, 1974: Table 2.1B).

(b) In the Basin of Mexico the archaeological evidence indicates a sustained population growth at an annual rate of 1.0% during the 150 years or so prior to the Conquest (Butzer, 1992a). This is a veritable demographic explosion that would have required a considerable expansion as well as intensification of agricultural land use. The cultural landscapes of central Mexico in 1519 bear this out, with extensive agricultural landforms (such as *chinampas*, semiterracing, and terracing) and an expansion and greater complexity of irrigation networks (Whitmore and Turner, 1992). Presumably this would also have put considerable pressure on adjacent woodlands on rougher terrain used for fuel and timber. To support even a conservative population figure, marginal and unirrigated cropland would have had to be cultivated on a perennial basis (Williams, 1989). Not surprisingly, excessive pressure on sloping, marginal land led to prehispanic soil erosion (Werner, 1986; Carlos Córdova, pers. comm., 1992).

(c) Indian demographic collapse 1519-1620 as a result of epidemic disease led to widespread abandonment and sale of indigenous cropland (Prem, 1992), and presumably

also to disintensification in those areas not abandoned. As a small minority, the Spanish settlers were almost totally dependent on indigenous labor, which remained in short supply well into the eighteenth century. Consequently Spanish agricultural activities could not possibly pick up the slack, from which it follows that areas of earlier indigenous agriculture could not all be kept in cropland, and even areas of persistent farming would have been subject to some disintensification. This can be illustrated by the hypothetical scenario of Table 3, which assumes an indigenous population of 10 million in 1519 and 1.3 million in 1620-50; further assuming 4.0 persons per family in 1519 (with demographic expansion) and 3.3 per family in 1620-50 (with demographic regression), the number of households would have declined from 2.5 million to 0.4 million. Setting an arbitrary figure of 10 ha of land permanently or periodically cropped by one household, and assuming that urban families without farm plots would need to be similarly supported, the total area directly affected by agricultural activities would have declined from 250 000 to 40 000 km^2. Yet only 4000 km^2 of cropland were awarded to Spaniards, including the new agricultural districts of the Bajío (Table 2). Even if this figure is incomplete, and is rounded up to 10 000 km^2 to include occult purchases, it implies that cropland was reduced by about 80% in less than 100 years. Changing any of the initial assumptions, within broadly acceptable limits, would only increase the estimated decline. In effect, this conservative scenario argues that the abandonment of cropland (or the implied conversion of cropland to pasture) was catastrophic, and the Spanish colonists were not even remotely capable of making up the difference.

(d) If the high estimates of sheep, cattle, and horse pasture land of Table 2 are used in Table 3, the total area of Spanish effective land use is increased by 125 000 km^2, but that still leaves 75 000 km^2 (30%) unutilized or underutilized, by the standards of 1519. The implication is that substantial areas, especially outside of the Basin of Mexico, were allowed to revert from cropland or fallow to woodland or scrubland, presumably used seasonally as off-site pasturage. A corollary inference is that, despite Spanish interdictions against giving *estancia* titles for former cropland, most of the *estancias* granted outside of the environs of Mexico City and Puebla (and within the former sedentary zone) must have been located on abandoned indigenous farmland. That would certainly be the case in the *tierra caliente*, where vegetation specified in the land grants (in area B1, Figure 3) after 1575 suggests a "cultural savanna" with characteristic *coyole* palms, and local clusters of prehistoric mounds (*cués*) or of agaves and prickly pear (*maguey*, *nopal*).

Table 2. Summary Estimates for the Spanish Land Allocation in Nueva España, 1620-50

Area of Veracruz, San Luís Potosí, Guanajuato, Querétaro, Hidalgo, Mexico State, Puebla	- about 250 000 km^2.
Agricultural Land *Caballerías* awarded to Spaniards	- about 9000 titles (close to 4000 km^2); - 58% within 120 km of Mexico City; 20% in Bajío.
Sheep Grazing (*Estancias*)	- about 2000 titles for home-base *estancias* (15 600 km^2 recorded, but probably closer to 25 000 km^2); - almost exclusively on plateau, eastern Puebla to eastern Bajío; - about 1000 titles for winter pastures (*agostaderos*) (7800 km^2, but probably closer to 25 000 km^2); - representing 6 to 8 million sheep.
Cattle Grazing (*Estancias*)	- at least 2000 titles awarded (35 000 km^2, but probably closer to 70 000 km^2); - mainly in Gulf Lowlands, Toluca, western Bajío, and Jalisco lake district; - representing 1.5 to 2 million cattle.
Horse and Mule-Breeding (*Estancias*)	- about 200 titles awarded, mainly in the Huasteca (3500 km^2, probably representing some 5000 km^2); - representing perhaps 150 000 equines.
Area of Nueva España	- about 500 000 km^2.
Land Controlled by Spaniards	- about 130 000 km^2 (26% of Nueva España).
Indian Agricultural Domain (*Patrimonio primitivo*)	- perhaps 220 000 km^2 (44% of Nueva España).
Non-Agricultural Domain	- perhaps 150 000 km^2 (30% of Nueva España). (*Tierras baldías*)

Table 3. Scenario for Land-Use Change in Nueva España after the Conquest[1]

Period	Indigenous Cropland/Fallow	European Cropland/Fallow	European Pasturage	Total Agropastoral	Total Population
Before 1519	250 000 km²	---	—	250 000 km²	at least 10 million
Ca. 1620-50	40 000 [2]	10 000	125 000	175 000	about 1.5 million

[1] Based on assumptions listed in text.

[2] Implies disintensified use, by smaller families.

In effect, early Colonial land use marked a significant retraction compared with that during the decade or two prior to 1519. The next question is whether the new component of Spanish land use had a different or greater environmental impact than indigenous activities did before 1519. That can only be answered in part because the methods of environmental history do not provide the type of resolution that a biologist would require to assess range management or contemporary environmental impacts.

What we can do at this point is discuss the different categories of paleoenvironmental information currently available, and then amplify this specific information by sketching out some general inferences in regard to changing land cover. Contributions to the environmental history of the Spanish colonial era in Mexico include palynology and limnology, travellers descriptions, vegetation described in land-title deeds, soil erosion and changing hydrology recorded by alluvial geology, and documents referring to tree-cutting and the use of fire to modify vegetation.

(a) Detailed pollen cores have been studied from the Gulf Coastal Plain (Tuxtla, southeast of Veracruz), the Basin of Mexico (Tlapacoyan, Teotihuacan), Tula, Michoacan (Lakes Zacapu and Patzcuaro), the Bajío (Parangueo), and a number of shorter cores further north and west. These materials have been presented, reviewed, or discussed by Brown (1985), and also Butzer (1992a), Butzer and Butzer (1993). In

each case, the major periods of ecological disturbance predate the Spanish Conquest, most pertaining to the Classic or Early Post-Classic, but some also to the Formative. The Colonial period, as recorded by very few samples in such profiles, saw only moderate levels of disturbance, in part with some degree of forest regeneration or improvement of grass versus compositae, in part with subsequent evidence of increasing disturbance, during the eighteenth or nineteenth centuries. In no case does the historical segment of these profiles include any early phase of weed explosion and arboreal decline. The available pollen cores do not, therefore, record significant environmental disruption after the Conquest, and at least not until the eighteenth century.

(b) A comprehensive limnological study from Lake Patzcuaro (O'Hara *et al.*, 1993) now provides a three-dimensional picture of a catchment and its changing soil landscape over time. Three protracted episodes of soil erosion are indicated, the first beginning before 3000 B.P., the last approximately A.D. 1200. Neither mineral sediment nor charcoal increased after the Conquest, despite considerable Spanish settlement and seasonal stockraising in the basin since the 1540s. The results of this compelling study do not stand alone: lakes next to Classic Maya sites in northern Guatemala also show sustained accumulation of clays, organic matter, and phosphates in lake cores during the period of indigenous occupance (Rice *et al.*, 1985). These cases imply that the burden of proof now lies with those who claim that cumulative Spanish land use was more environmentally destructive than its indigenous counterpart.

(c) Spanish officials of the sixteenth century were excellent environmental observers, leaving numerous good route descriptions or district reports. Our evaluation of this record --including the *Suma de Visitas* of about 1550 (Paso, 1905a/b), the parish reports of about 1570, over 200 *relaciones geográficas* of 1577-85 (e.g. Acuña, 1984, 1986, 1987), the Ciudad Real (1591) diary of 1585-89, and the Mota y Escobar (1605, 1623) descriptions of Nueva Galicia (around 1605) and the diocese of Puebla-Tlaxcala (about 1608-23) -- permits a comprehensive overview of vegetation during the period 1550-1620. Large-scale patterns of physiognomic vegetation recorded on the aerial photography of ca. 1970 (and its derivative topographic maps) are quite similar to those of the earliest Spanish reports that date within a few decades of the first livestock grants. Several Indian maps accompanying the *relaciones* also represent vegetation well, including complex communities of succulents and agaves that require many decades to establish (e.g. for Zempoala, see Butzer and Williams, 1992), in the same places they are found today. This all supports the pollen evidence, that the basic distribution of forest,

live-oak steppes, and *matorral crasicaule* observed today was already established in prehispanic times, and that there is no apparent evidence of degradation during the late 1500s. By contrast, travellers of 1765-1830 (Ajofrín, Morfí, Berlandier) describe examples of patently degraded vegetation north and northwest of the Bajío. Relevant here is that the intendant of Guanajuato in 1796 was ordered to inaugurate a program of afforestation, to revitalize timber growth, protect the water supply of the town, and prevent erosion (Dusenberry, 1963: 170-71).

(d) For the Bajío we have assembled some 250 descriptions of local vegetation and hydrology, recorded in title deeds dating from 1542-91, and compared these with the same settings today (Butzer and Butzer, 1993). They show that woodland was slightly more expanded; that unlike today, rivers were accompanied by dense riparian forests of mesquite or *Taxodium*; and that there was no tangible evidence for disturbance after 50 years of stockraising in areas of Spanish settlement. Some of the riparian forests have only been destroyed since the 1830s. In some areas of traditional Indian agriculture, however, the vegetation was degraded, and in one case a Spanish observer interpreted a forest clearing with disturbed vegetation as *prima facie* evidence for an abandoned Indian settlement. Melville (1983, 1990) has assembled evidence from the *mercedes* for the Valle de Tula, claiming significant degradation after 1590. We disagree with some of her criteria (Butzer, 1992a), and our ongoing analysis for 1592-1642 for the area where our studies overlap does not support her conclusions.

(e) The most sensitive indicator of ecological change across a watershed is provided by floodplain sediments, because degraded vegetation and soil erosion lead to accelerated alluviation by higher peak floods. In the Laja drainage near San Miguel, there was no change in hydrology from before 1500 until about 1750 or 1800 (Charles Frederick, pers. comm., 1992). The earliest destructive floods in the Bajío (Guanajuato, Celaya) are recorded from the mid-1700s. Similar alluvial studies are currently underway in the Basin of Mexico and in Oaxaca by C. Córdova, C. Frederick, and C. Rincón Mautner at the University of Texas.

(f) The *mercedes* also include licenses to cut trees and interdictions against burning pasture. It is well known that 6000 timbers were cut shortly after the Conquest to provide beams for the government palace in Mexico City. This is not excessive in light of data from Medieval Europe, that 500 to 600 beams were required for an average

church roof, and ten times that many for a monastery (Haas, 1990), values identical to those cited from Mexico City during the 1500s. The *cabildo* of Mexico City directed that timbers should be cut in the mountains, so as not to eliminate shade trees and windbreaks for pasturage in the foothills (so in 1533, Orozco y Berra, 1859: III, 56-59). During at least the 1540s and 1550s timbers for construction could only be cut by license. The accelerated building of churches and monasteries from 1560-90 must have led to considerable deforestation in limited areas that were also used to graze sheep. The mountain streams of the Basin of Mexico nonetheless continued to provide a reliable source of water for irrigation, grist and fulling mills, as well as sawmills, at least through the 1630s, judging by licenses granted. The voracious demands of towns for timber and fuelwood was not a uniquely Hispanic trait: the steep uplands around Classic Copan (Honduras) were more or less totally deforested (Abrams and Rue, 1988), and in the Guatamalan Classic Maya region, the Petén rainforest was completely removed during the same period (Vaughan *et al.*, 1985). It evidently does not require iron axes or sheep and goats to denude commonage!

(g) Whereas the Indians did not use fire in hunting drives (see Torquemada, 1610: I, 611-12), after the Conquest Indian or African herders burned pastures to improve grazing for their employers' livestock. The practice was severely fined by the viceroy, based on early *mercedes* from Toluca and Michoacan; yet Ciudad Real (1591: II, 128-29) in 1587 described such deliberate burning of transhumant sheep pastures in Jalisco. The Spanish practice to periodically burn *matorral* must have been transferred to the New World, and apparently was difficult to stop.[2] In 1571, the parish priest of Veracruz also described how fire was used to remove old, non-nutritive savanna grasses every two years (Paso, 1905c: 195). These isolated examples suggest that fire was used, perhaps commonly so, in pasture management. That would favor grass over *matorral,* and inhibit the expansion or regeneration of arboreal vegetation. Curious enough, despite the contemporary impact by *carboneros* on Mexican forests, we have not yet found early

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2. The expanded ordinances of 1574 for the Mexican *mesta* included a paragraph that declared setting fires in woodlands (*montes*), fields (*campos*), and savannas as disadvantageous in general and in particular, especially because it damaged livestock pastures (Bentura, 1787: II, 62, item 81). Other ordinances of 1579 stipulated that anyone setting a fire in the *monte* or around it, in a manner that might damage that *monte*, would be severely punished; other prohibitions in the same set included the cutting of trees, and the gathering of fuelwood by cutting a tree at the base, rather than its branches (Bentura, 1787: II, 68). In regard to the comparative advantages of burning in the Mediterranean Basin, see Trabaud (1991) and Lewthwaite (1981).

Colonial documentation referring to charcoaling activities.

This summary of a substantial body of information on potential vegetation and land cover change in early Colonial Mexico shows that the questions initially raised are difficult to resolve. We suggest several tentative conclusions:

(1) Prehispanic land use in some regions, and at different times, had profound environmental impact. This suggests that high population densities lead to significant biotic change and local degradation. Spanish settlement intruded on an environment already extensively used for agriculture, with partial removal of woodland.
(2) Spanish livestock raising and related management practices did not immediately lead to ecological deterioration, neither in areas beyond the agricultural frontier of 1519, nor in old settlement areas, where Indian demographic collapse simultaneously reduced population pressures. Whether the switch from indigenous farming to Spanish stockraising led to qualitative changes in the ground cover, such as shifts from grasses to compositae or woody shrubs, cannot yet be ascertained.
(3) In at least some areas, Spanish livestock practices eventually did lead to biotic degradation and soil erosion, probably during the eighteenth century, when overall population density increased rapidly. It is by no means certain that this was a general phenomenon; more probable is that landscape histories varied considerably from place to place.
(4) In at least some areas, soil erosion dates to Post-Colonial times, possibly the late nineteenth century. Most of the soil erosion conspicuous in several parts of Mexico today, such as badlands, gullying, or shoestring erosion, is quite recent. As often as not, it is the result of injudicious cultivation efforts.
(5) Despite such cases of ecological disturbance during the last 2500 years, in most regions the basic patterns of residual, natural vegetation probably continue to reflect climate, topography, and substrate as much as they do cultural intervention. Thus the Río Tula floodplain from well above Ixmiquilpan down into the deep gorge to the Moctezuma River confluence continues to be fringed by an unbroken riparian forest of ancient *Taxodium* trees, documenting long-term systemic equilibrium and landscape stability, in one of the bleakest environments of Central Mexico.

In sum, introduction of the Spanish livestock economy to Nueva España did not lead to dramatic ecological repercussions. There was land-cover change, but it was subtle and long-term, possibly remaining insignificant until two or three centuries after the

Conquest. The explanation for this apparently counterintuitive conclusion should probably be sought in the mobile, extensive management practices introduced to Mexico and derived from many centuries of Mediterranean pastoral experience. The Spaniards were evidently well aware of the dangers of overstocking animals on fixed, dry-season pastures, and adhered to a highly mobile management strategy, in order to limit environmental impact. That strategy happened to be detrimental to Indian farming, because of periodic trampling or devouring of crops. But the viceregal government made serious efforts to assure that damages were recompensed, by the same method of adjudication applied in the case of the Castilian *mesta*. In the meanwhile, the Indians profited from the subsistence security, balanced nutrition, and invaluable fertilizers provided by the much-maligned Old World livestock.

The Northern Livestock Frontier: 1650-1890

After 30 years of economic recession, with falling mine production and sales tax receipts (*alcabalas*), new silver strikes and fresh capital revived the economy of New Spain during the late 1660s. Thereafter, with exception of the crisis of the late 1690s, the economy continued to grow until the eve of insurrection in 1810 (see annual revenue data in TePaske, 1976). This process favored urban growth, proto-industrialization, and agricultural intensification in Nueva España. Further north it led to continuing settlement expansion, that shifted the center of livestock production toward the new and still unstable frontiers (Trautmann, 1986).

In Nuevo León, the number of transhumant sheep increased from 300 000 in 1648, to 555 000 in 1680, and one million in 1715. From its beginnings, the great *mesta* treks to Nuevo León had only been possible for wealthy owners, who sent individual flocks with an average size of 25 000 to 30 000 head into hostile Indian country, accompanied by up to a 100 *pastores* (Cavazos, 1961; Hoyo, 1972). The major attraction of modern Tamaulípas, Nuevo León, and northern Coahuila was the combination of winter rains and only sporadic frosts. While other pasture lands of Central and North Mexico were parched and dormant, those of the Northeast were green, and water was abundant (see Alonso de León in Cavazos, 1961). Flocks were pastured here from late November to late April. Then, after they had lambed, the endless lines of ewes and their young returned, to be sheared in the eastern Bajío, or driven on to the meat markets of Mexico City.

Owners of smaller flocks only drove their sheep intermediate distances, to safer *agostaderos* in the valleys or foothills on the Pacific or Gulf slopes--the Huasteca,

Michoacan (Morin, 1979: 37-38), or Jalisco-Nayarit (Serrera, 1977). Whatever their targeted pastures, the transhumant sheep had to be very hardy to survive long trails etched through thorny or succulent scrub (*matorral e nopaleras*), with widely spaced waterholes (see Alonso de León in Cavazos, 1961). The fine-fleeced merino sheep of the sixteenth century had disappeared by Humboldt's time (1811: 299), leaving only the all-purpose meat and wool breed (*raza churra*). The hard plant debris embedded in the fleece was almost impossible to remove, with the result that textiles were generally woven from coarse and dirty wool.

After 1700 the trend was towards permanent stocking of the northern pastures. A small wool center developed in Saltillo, and both large and small owners of sheep or cattle began to establish themselves in Nuevo León. During the 1750s Tamaulípas, until then controlled by mobile or semisedentary Indians, was "pacified" by an elaborately planned military occupation and settlement program. In 1757, 914 000 sheep belonging to eight individual or corporate owners in Querétaro were wintering here. By 1795, there were 112 000 cattle, 389 000 sheep, and 141 000 goats resident in Tamaulípas, while in Coahuila one great estate ran over 200 000 sheep. On the eve of independence, there were a million cattle, 5 million sheep, a million goats, and 35 000 pigs in northern Mexico (see Florescano and Gíl, 1976), with perhaps another 5 million sheep in Nueva España (Humboldt, 1811). The era of long-distance transhumance in Mexico was drawing to a close, and much like in Spain, more local movements of animals (*travesío*) became increasingly characteristic, within a range of 30 to 80 km.

Meanwhile, around the margins of the Bajío and in Hidalgo, the rock-walled sheepwalks or *cañadas* not only continued to be used, but even expanded, as the interdigitation of livestock and agriculture became tighter, with sheep kept in mountain pastures during the winter, wheat growing season, then descending into the interstitial land among standing crops of corn, barley, and vetch during the summer (Butzer, 1989b).

The wars of independence (1810-21), marked by long bouts of guerrilla conflict, widespread banditry, and almost uncontrolled military requisitioning, threw the livestock economy into disarray and completely disrupted the Mexican *mesta*. With the return of peace, the herds were sadly depleted, start-up capital was lacking, and the uncompetitive regional wool centers succumbed to foreign, factory-made textiles, as trade barriers were removed. In Nuevo León, the number of sheep and goats decreased from 1 115 000 in 1810, to 661 000 in 1832, and 403 000 in 1850, while the proportions of sheep and goats were reversed. Thereafter large estates in northern Mexico favored sheep, while

the rural population stocked goats for subsistence purposes. Only in New Mexico and Arizona, where Indian blanket weaving had become a lasting tradition, did the sheep population continue to increase steadily, until the end of the century (Denevan, 1967).

With Mexican independence, two centers of cattle-raising emerged north of the present border, in California and Texas. These were to play a major role in the settlement of the western United States. Alta California had 92 000 cattle in 1803, that expanded to 425 000 head by 1834. American occupation in 1846, followed by the gold-mining boom, created an immense demand for beef, with a corresponding expansion of the herds. It was from this Hispanic center of cattle-raising that cattle ranching in the American Far West -- counting almost 10 million head in 1880 -- was derived, particularly the secondary concentration in the Columbia Basin (Jordan, 1992).

In Texas, there were over 100 000 cattle during the late 1820s. Further cattle were then introduced to the eastern parts, from source areas in Florida and the Carolinas (Jordan, 1981; Jackson, 1986). In 1860, these herds had expanded to 3.5 million head, increasing to 4.5 million by the end of the Civil War (1865). Such phenomenal numbers of cattle, exceeding any previous counts in all of Mexico, only awaited market opportunities.

In 1867, cattlemen from Texas decided to drive a huge herd of open-range cattle some 700 km north, to the advancing railroad in Kansas. This major event opened the Abilene Trail, that created the phenomenal era of the Cattle Empire on the Great Plains (Bowden, 1980). The great spring trek to Kansas peaked with 700 000 animals in 1871, as the railroad network carried livestock to the burgeoning meat markets of Chicago and the East Coast. By then, a spectacular form of cattle transhumance began to span the whole of the Great Plains, from Texas to Montana, with the animals driven over 1500 km northwards in the spring and back again in the autumn, before the first snows. Cattle competed for the natural habitat of the buffalo. In 1884, a million head were driven north by 4000 *vaqueros* with 30 000 horses, marking the climax of the greatest transhumance system ever known.

But the days of the Cattle Empire were brief. Prices dropped as rail transshipment became efficient. Private ownership by homesteaders and small-hold ranchers began to close off the open range with barbed wire fences. Sheep vied increasingly for rangeland, and Wyoming in 1880 had 450 000 sheep in competition with 521 000 cattle, with the sheep spoiling pastures for cattle because of their habit of close grazing. Then, summer droughts and early blizzards hit the cattle transhumants hard during the decade after 1882. Finally, it was recognized, in 1886, that cattle could indeed be pastured on the northern Great Plains during the winter because the warm chinook winds, a foehn effect

downwind of the Rocky Mountains, periodically melted off the snow. In a scant 20 years, this monumental cattle transhumance strategy, based on Texas, had become obsolete.[3]

By then, the American West was well on its way towards a more diversified economic development. Cowboys were rapidly displaced by farmers, miners, and small-town merchants, who looked eastward, to an increasingly standardized America, that stood under the sign of its new industries. The anachronistic pastoral economy lived on only in film and fiction. But, modelled so closely on the Spanish *mesta*, it represented the final act in the great drama of Hispanic livestock raising, an abrupt and stunning conclusion worthy of a play by Lope de Vega.

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3. Surprisingly enough it remains impossible to establish whether or not nineteenth century Anglo-American land use -- let alone a more specific question such as stockraising prior to the introduction of barbed-wire fencing -- led to local or general environmental deterioration in the Great Plains or West. Quaternary geologists and paleoecologists have not yet turned their attention to such fine-grained and applied problems, but equally important is the potential of using documentary evidence, which ranges from vegetation described in land deeds to early photography. Interesting is that Denevan (1967) found no correlation between nineteenth century Hispanic livestock numbers in New Mexico and the onset of gullying.

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