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# People, sheep, and landscape change in colonial Mexico: the sixteenth-century transformation of the Valle del Mezquital

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PEOPLE, SHEEP, AND LANDSCAPE CHANGE IN COLONIAL MEXICO:  
THE SIXTEENTH-CENTURY  
TRANSFORMATION OF THE VALLE DEL MEZQUITAL

A Dissertation

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in partial fulfillment of the  
requirements for the degree of  
Doctor of Philosophy

in

The Department of Geography and Anthropology

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## **LIST OF ABBREVIATIONS**

AGADE – ARCHIVO GENERAL AGRARIO, DOTACIÓN DE EJIDOS

AGNGP – ARCHIVO GENERAL DE LA NACIÓN, RAMO GENERAL DE PARTE

AGNI – ARCHIVO GENERAL DE LA NACIÓN, RAMO DE INDIOS

AGNIV – ARCHIVO GENERAL DE LA NACIÓN, RAMO DE INDIFERENTE VIRREINAL

AGNM – ARCHIVO GENERAL DE LA NACIÓN, RAMO DE MERCEDES

AGNT – ARCHIVO GENERAL DE LA NACIÓN, RAMO DE TIERRAS

## ABSTRACT

The causes of central Mexico's environmental degradation are poorly understood. Scholarly contention centers on the role of introduced livestock as agents of soil erosion. This dissertation explores New Spain's sixteenth-century livestock ecology by drawing upon archival and field data to reconstruct the spatio-temporal characteristics of sheep ranches in a southeastern section of central Mexico's Valle del Mezquital. The introductory chapter outlines a scholarly disagreement from the 1990s that underscored differences between historical and geographical approaches to studying historical landscape transformations. On one side of this debate, geographer Karl W. Butzer finds in the sixteenth-century Mexican Bajío little evidence for environmental degradation from introduced livestock. On the other, environmental historian Elinor G.K. Melville's research in the adjacent Valle del Mezquital suggests that sheep devastated that region's environment by the sixteenth century's close. This section looks beyond the finer points of methodology in search of other reasons for their disagreement, namely researcher positionality. Chapter 2 addresses the methodological concerns that arise from using colonial-era Mexican archival sources to study landscape transformations. This chapter outlines how previous scholars have approached these concerns and how this dissertation handles each of them. The discussion then turns to perceptions of environmental cause-and-effect with an emphasis on agricultural terrace abandonment as a possible mechanism of environmental degradation. The second chapter also reviews basic concepts in rangeland ecology. The two subsequent chapters focus on the natural environment and the pre-Hispanic inhabited environment together attempt to establish an ecological baseline with which to evaluate colonial-era landscape transformations. Chapter 5 leverages the relatively small size of this dissertation's study area to map many of the sheep ranches to a relatively precise degree. A time-series of maps

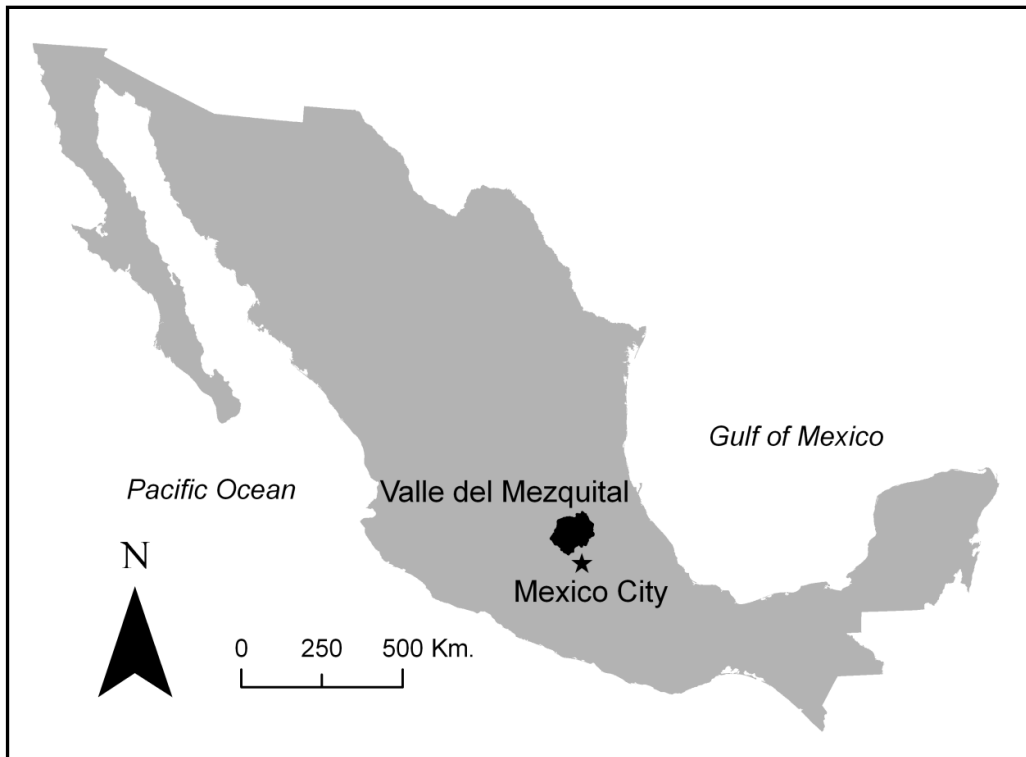
reveals the spatio-temporal development of the study area's sheep ranch complex. A Geographic Information System analyzes the various spatial characteristics of each ranch's location. This analysis emphasizes the reality of a three-dimensional landscape by considering the aspect, slope, and elevation of the ranching complex. The significant findings are: agricultural terrace abandonment likely instigated some of the region's soil erosion; there appears to have been fewer sheep in the study area than previously thought; deep drought conditions operated synergistically with herbivory and land abandonment in the late sixteenth century to transform the Valle del Mezquital into the degraded region it is today.

## CHAPTER 1: UNDERPINNINGS

### Introduction

In the 1490s Spaniards introduced various livestock species into the West Indies (Crosby 1972; Watts 1987). The animals reproduced at least as well as in Europe and soon Spaniards were shipping tallow, lard, hides, and dried meats back to Spain (Sauer 1966). As an ambulatory meat supply, livestock accompanied the Spaniards who explored what would become the Viceroyalty of New Spain. By the end of the 1520s, sheep and cattle herds had become well established in the colony (Doolittle 1987; Sluyter 1996). The growth of New Spain's mining economy later in the sixteenth century further increased the colony's demand for meat and a variety of other animal products (West 1949, 57).

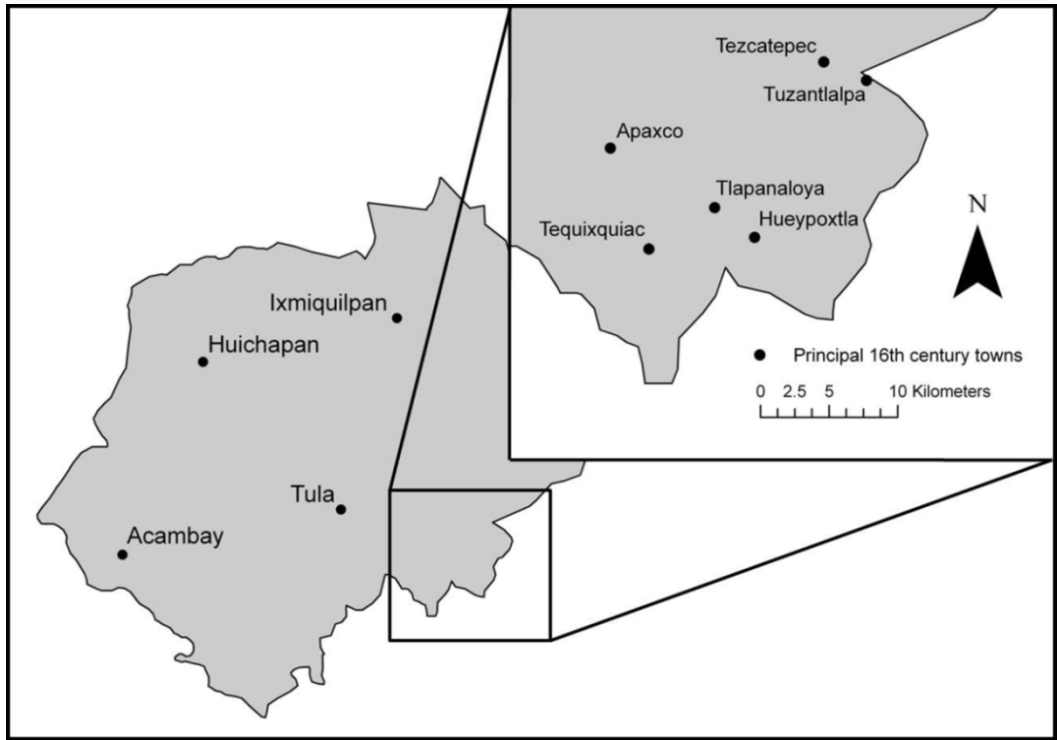
For decades Latin Americanist historical geographers have engaged colonial-era Spanish documents to study New Spain's sixteenth-century livestock ecology. Most of their study areas were in central and coastal Mexico, including Puebla (Prem 1988), the Bajío (Butzer and Butzer 1993), the central Veracruz lowlands (Sluyter 1998), and Michoacán's Tepalcatepec lowlands (Barrett 1973). These studies have intellectual roots that reach back into the middle decades of the last century. Most are outgrowths of the pioneering work of historical demographers and geographers at the University of California, Berkeley (Van Young 2004, 301).<sup>1</sup> Continuing in that tradition, this dissertation explores the processes of environmental transformation in central Mexico's Valle del Mezquital during the Early Colonial Period (1521-1620CE) (Figure 1.1). In 1992, William Denevan (1992, 376) signaled for resolution of the debate surrounding the role of introduced livestock as agents of environmental degradation in Mexico. This dissertation responds to his appeal by reviewing the methodologies of previous scholars as well as mapping the spatio-temporal development of early-colonial sheep ranches (*estancias*) in a relatively small study area in central Mexico.



**Figure 1.1.** The Valle del Mezquital

The study area comprises the southeastern portion of the Valle del Mezquital, which in the pre-Hispanic era was called the *Teotlalpan*, or “land of the gods” in Nahuatl (Paso y Troncoso 1905 v. 1, 217, v. 6, 26, 32; Cook 1949a). The study area roughly corresponds to the modern municipalities of Apaxco, Hueypoxtla, and Tequixquiac in Mexico state (Figure 1.2). However, I am specifically concerned with the administrative jurisdictions of the colonial-era pueblos Apaxco, Hueypoxtla, Tequixquiac, Tezcatepec, Tlapanaloya, and Tuzantlalpa. There are no extant maps of these jurisdictions so it is impossible to strictly bound the study area. However, it is roughly 500-800 km<sup>2</sup> in spatial extent. This is much smaller than previous similar studies, which considered thousands of square kilometers (e.g. Sluyter 1995; Melville 1983). In the Late Postclassic Period (1350-1521CE) the Valle del Mezquital was densely populated (Gerhard 1993, 295) with irrigated fields in the humid lowlands (Paso y Troncoso 1905 v. 1, 2) and semi-terraced agricultural fields on the gentler

hillslopes (Rojas Rabiela 1991, 44-5). Today, the region's name is a byword for environmental degradation, and much of the region is irrigated by Mexico City's wastewater.<sup>2</sup>



**Figure 1.2.** The study area's principal sixteenth-century towns

The remainder of this introductory chapter proceeds in two main sections. The first section considers researcher positionality in knowledge construction. I am particularly interested in how the positionalities of geographer Karl W. Butzer and environmental historian Elinor G.K. Melville. Butzer and Melville have studied colonial-era environmental transformations in adjacent study areas of central Mexico that partially overlap, the Bajío and the Valle del Mezquital, respectively. Despite using the same kinds of archival documents they have reached very different conclusions about the role of introduced livestock. This section also serves to contextualize the present study within the relevant

literature. The second section naturally follows as a discussion of how archival sources can be woven into coherent historical narratives of environmental transformation.

### **Knowledge Construction**

Half a century ago C.P. Snow lamented in *The Two Cultures* how educational overspecialization had polarized the scientific and literary communities. He described these two communities as separated by a “gulf of incomprehension—sometimes hostility and dislike, but most of all lack of understanding” (Snow 1959, 4). Historical geography is not a “science” in the Popperian sense of testing falsifiable theories (Popper 1959). However, more frequently than environmental historians it is historical geographers who draw upon data and techniques generated by the natural sciences.<sup>3</sup> This likely reflects how students who specialize in a subfield of human geography are usually expected to also be conversant in one or more subfields of physical geography. Students of history generally encounter no such expectation along the path toward becoming environmental historians.<sup>4</sup> Despite the different emphases on coursework, when historical geographers rely primarily upon documentary sources few disciplinary watermarks usually remain to distinguish them from environmental historians (McNeill 2003). But there are exceptional cases that highlight disciplinary boundaries and add prescience to Snow’s observation. The causes of the Valle del Mezquital’s environmental degradation represents a scholarly debate that is well-known to Latin Americanist historical geographers and environmental historians alike. This case is particularly notable because the scholars are prominent figures in geography and environmental history – Karl W. Butzer and Elinor G.K. Melville, respectively. On the one side, Butzer largely exonerates introduced sheep as early-colonial agents of landscape degradation. On the other, Melville convicts them as a “plague” that by the sixteenth century’s close had ruined the biophysical environment. Throughout the 1990s various



articles dissected Butzer and Melville's methodological differences (see for example Sluyter 1998 and 2002). These articles did not bridge the chasm that separates their positions so much as provide soundings of its depth. Because Butzer and Melville ascribe the bulk of the region's degradation to different centuries with different agency, their positions are currently incompatible. In the next chapter I review their methodological departures. Here I seek deeper reasons than methodological differences for their incompatible positions. I begin by framing the academic context of their debate. I then draw upon feminist epistemology to explore how Butzer and Melville's positionalities may have influenced their perspectives and conclusions. This discussion emphasizes how philosophical and methodological approaches differentiate (environmental) historians from (historical) geographers (*contra* Guelke 1982, 192). This is partly why I have chosen a study area within the Valle del Mezquital – in order to reconcile, or if reconciliation proves unfeasible then at least to explain – the different conclusions of Melville and the geographers.

#### Framing the Debate

For decades Karl Butzer has been a leading scholar within geography. He is a Fellow of both the American Academy of Arts and Sciences and the National Academy of Sciences. His research combines geomorphological, archaeological, and archival data sources to understand human-environment interactions of the past. Before working in Mexico, Butzer studied agriculture, irrigation, and geomorphology in the Near East and Spain (see for example Butzer and Hansen 1968; Butzer 1976; Butzer *et al.* 1985). By the early-to-mid 1990s Butzer's attention had turned to the Mexican Bajío, which partially overlaps with the western Valle del Mezquital.<sup>5</sup> He maintains that the Spaniards consciously avoided landscape degradation by managing their flocks within a highly mobile system of transhumance. It is his view that this largely mitigated the negative environmental impacts of

herbivory in any one location. Butzer proposes that despite the damage livestock may have caused to agriculturalists' fields (*sementeras*), the agriculturalists benefitted greatly from the traction and manure that livestock provided them. He believes the landscape degradation in the Bajío today stems from injudicious agriculture during the eighteenth and nineteenth centuries when the native population began to recover from its nadir (Butzer 1992a and 1996a).

Elinor G.K. Melville's scholarship in central Mexico elevated her to prominence within environmental history. She completed her doctoral dissertation in 1983 on the early-colonial landscape changes in the Valle del Mezquital (Melville 1983). In her dissertation she correlates sixteenth-century references to high sheep grazing densities with coeval references to environmental degradation. The most common signs of degradation that Melville identifies are desiccation and a trend in the vegetative community towards spiny, arid-zone species. She argues that Spaniards – in their ignorance of the range's carrying capacity – allowed unsustainably large sheep flocks to replicate geometrically and permanently reduce the region's agricultural and pastoral productivity.<sup>6</sup> Although Melville (1994) assigns partial blame to the lime burners who deforested higher elevation woodlands to fuel their lime kilns (*caleras*), she concludes that sheep overstocking is by far the most powerful explanation for the Valle del Mezquital's environmental degradation.

In 1994 Cambridge University Press published Melville's dissertation under the title *A Plague of Sheep* (Melville 1994). The only significant difference between her dissertation and book is that the latter's degradation narrative is propelled by the "irruptive oscillation" model developed within rangeland studies. This conceptual qualitative model describes ungulate population dynamics when these animals enter a new environment. It maintains that an ungulate population will crash after the population peaks and the food supply is

depleted. Pasture quality will have been permanently degraded by the oscillation's end. Melville aligned the stages of the irruptive oscillation with documentary references to stocking densities and vegetation change. In this way, the model verified her archival research and vice-versa. I consider this model more fully in the next chapter.

The eleven years between her dissertation and book suggest that the incorporation of this model imbued her regional study with wider applicability and more explanatory power. Whatever accounts for that temporal lacuna, *A Plague of Sheep* was well-received among environmental historians. The Conference on Latin American History awarded it the Bolton Prize and it is now assigned reading within some environmental history courses (Morse 2003). One reviewer of *A Plague of Sheep* explains, "Its implications are not limited to Mexico, nor to the early modern period" (Schwaller 1994, 964-5). James Axtell (1995), a noted historian of North American indigenous cultures, places Melville among environmental history's recent luminaries. Elinor Melville passed away only twelve years after her book's publication.

The Butzer-Melville debate was at its most active in the early-to-mid 1990s. The remainder of that decade saw other geographers become aligned with Butzer to underscore just how deeply this debate falls along disciplinary lines. In his study of the early-colonial central Veracruz lowlands Sluyter (2002) found that cattle were environmentally benign in the Early Colonial Period. In the central Mexican state of Michoacán Endfield and O'Hara (1999a) have found little evidence in the historical record to suggest that Spanish land-use systems, including pastoralism, resulted in significant sixteenth-century land degradation. Rather, they propose that the sixteenth-century descriptions of failing hydrology that Melville had attributed to sheep overstocking were in actuality the effects of a severe

drought. I am unaware of any rebuttals that Melville made in response to the critiques coming from geographers.

### Positionalities

The influential environmental historian William Cronon believes that historians necessarily rely upon narrative to order the past and extract meaning from it. This entails constructing story plotlines that nature does not actually possess – stories that an historian weaves with an internal set of biases, motivations, and beliefs (Cronon 1992). This is congruent with the feminist perspective to which some historical geographers are increasingly turning in their scholarship (Holdsworth 2002). Scarpaci (1992) recommends that Latin Americanist geographers in particular should move beyond description to incorporate social theory into their scholarship. Feminist standpoint theory maintains that no scholar – whether in the humanities or natural sciences – is able to completely escape the many aspects of his or her biography and personality, or *positionality*. Feminist epistemologist Sandra Harding suggests that scholars practice a “strong reflexivity” to explore their positionalities in order to maximize objectivity. Harding advocates reflexivity throughout the research process “because culturewide (or nearly culturewide) beliefs function as evidence at every stage in scientific inquiry: in the selection of problems, the formation of hypotheses, the design of research (including the organization of research committees), the collection of data, the interpretation and sorting of data, decisions about when to stop research, the way results are reported, and so on” (Harding 1993, 69). Some scholars within geography have called for similar reflexivity in order to promote basic intellectual growth and improve researcher objectivity in both archival and field work (England 1994; Sack 1997; Cameron 2001; Moser 2008).<sup>7</sup>

On the surface, Butzer and Melville's different views arise because of the finer points of methodology that I discuss in the next chapter. But consideration of their positionalities may help to uncover how they each created distinctly situated knowledges. I begin with Butzer's positionality, which can be approached through a short autobiographical essay he penned in 2002. His early scholarship as an academic reflects his childhood interests. He writes that as a child having his father read aloud to him from a German encyclopedia on Oman he "became fascinated with an unusual kind of historical geography, namely the nineteenth-century Near East and Africa" (Butzer 2002, 59). After completing his undergraduate studies, he vacationed in Spain where "The warmth of those simple country people activated the powerful historical landscape that drew me back to Spain time and again across some forty years" (Butzer 2002, 62-3). As already mentioned, by the early 1990s Butzer's research interests had – like so many Spaniards in the sixteenth century – migrated to New Spain. Even more than usual, the early 1990s was an exciting time to be a Latin Americanist historical geographer. In 1992 a special issue of *Annals of the Association of American Geographers* outlined current historical geographical research on the Americas around the time of Conquest (Butzer 1992b). Butzer served as the guest editor and contributed two pieces. This special issue has been a powerful force to dispel the "pristine myth," which portrays the pre-Columbian Americas as lightly populated and little altered by indigenous peoples.<sup>8</sup> The following year in the journal *Nature* Butzer (1993) authored a contextual essay for an article by O'Hara *et al.* (1993) that reinforced the central message of the aforementioned *Annals* issue.<sup>9</sup> O'Hara and her colleagues analyzed 21 lake sediment cores from central Mexico's Lake Pátzcuaro and found that soil erosion rates were at least as high before Conquest as after. This empirical evidence reaffirmed for Butzer that the pre-Columbian New World was "no Eden." The identification and rejection of the "pristine myth"

was a signal accomplishment within historical geography. Yet some scholars leveraged the intellectual capital that debunking the “pristine myth” had generated to dismiss Melville’s thesis on sheep overstocking. Labeling her an adherent of the “pristine myth” had become a kind of intellectual judo that threw her argument to the ground without actually confronting it head on. Indeed, O’Hara *et al.* mischaracterize Melville as a subscriber of the “pristine myth.”<sup>10</sup> Dore (1994, 52) then draws upon O’Hara *et al.*’s article in *Nature* to label “naive and romantic” scholars who would lay the blame for early-colonial environmental degradation squarely at the hooves of livestock. The following year Butzer and Butzer (1995, 172-3) proposed that such scholars are either seduced by the “pristine myth” or harbor “an old and deep-seated bias by North European scholars and travellers against Mediterranean pastoralism.”<sup>11</sup>

We can also assess Butzer’s positionality from two book reviews wherein he provides his estimation of environmental history. The first Butzer wrote in 1996 for J.R. McNeill’s *The Mountains of the Mediterranean World: An Environmental History*. Here Butzer (1996b, 780) suggests that, “The ‘new’ environmental historians appear to prefer literary over empirical evidence.” These “new” environmental historians were primarily intellectual and political historians who made the environment their primary object of study during the late 1960s and early 1970s (White 1985; Baker 2003). They founded the American Society for Environmental History in 1977, the organization that publishes the refereed journal *Environmental History*. Before the 1970s there were of course scholars in many other disciplines who studied environmental change in an historical context. Here one need only think of Carl Sauer and the Berkeley School of geography (Mathewson and Kenzer 2003). I hope without assuming too much, “environmental history” for most of today’s geographers and historians refers to a subdiscipline of history, with all the methods and stylistic nuances

that such an association entails. Since environmental history's inception, its practitioners have more frequently turned to the works of social scientists than the works of natural scientists to expand their narratives (Nash 1972). Many environmental historians recognize that scientific, empirical evidence can enhance their research yet many have never been trained to engage these data sets (Hughes 2008). Butzer (1996b, 781) goes on to note that McNeill's book "is not the environmental history of a geographer or biologist." Here the problem crystallizes that McNeill and Butzer are communicating past one another with their different conceptions of environmental history. In this way, different conceptions of the field means that different people could regard *The Mountains of the Mediterranean World* as a successful or inadequate contribution to it.

The second review Butzer wrote in 2000 for Charles L. Redman's *Human Impact on Ancient Environments*, providing a venue for him to expand his thoughts on environmental history. Butzer (2000, 2427) cautions, "When scholars in English departments can heap indignation on Spaniards for their alleged despoliation of the New World, environmental history risks losing its anchor in pragmatic data to postmodern discourse." He never identifies those scholars, so perhaps his example is imagined. His point is that primarily textual historical landscape studies ought to include other independent lines of evidence. In 2005 Butzer (2005, 1773-4, 1795) clarified his position on this front:

Environmental history can be viewed as an overarching framework within which several clusters of researchers (re)examine diverse but fundamental issues, ranging from climatic and environmental change to development, famine, and global inequities. That thematic diversity extends into the epistemological and methodological realm . . . Environmental history must be grounded in sound empirical data, acquired by theoretically informed research, and tempered by repeated reflection on the validity of assumptions. . . . Natural science and social science must be combined; each theoretically informed but inductively engaged, with both vantage points working in complementary concert.

By (re)defining environmental history in this way Butzer essentially calls for the establishment a new multi-disciplinary field. Few if any scholars would fault Butzer for championing such an endeavor. However, environmental history structured as such would be impracticable to many “historian environmental historians.”

Review of Melville’s positionality is enhanced by her dissertation’s preface and her biographical details that became public after her passing. These sources reveal that long before her graduate studies Melville had developed a certain perception of the environmental impact of sheep ranching. She discloses in her dissertation’s preface, “Having seen at first hand the effects on the New Zealand and Australian landscapes of relatively short periods of exploitation by sheep grazing (80-170 years), I thought that the deterioration in the natural resources of the Valle del Mezquital during the last twenty years of the sixteenth century might possibly have been caused by overgrazing sheep” (Melville 1983, v).<sup>12</sup> Her dissertation proceeds to confirm this narrative. This may be unsurprising in light of her childhood association with sheep. Melville’s obituary recounts, “Her father was a supervisor of British mines there [Papua New Guinea]; she and her mother caught the last flight out of the country before the Japanese invaded in WWII and went to stay with her father’s only relatives, two spinster sisters living in Australia. When her father died four years later, her mother, tired of living under the matriarchal rule, moved them to New Zealand, where they lived on a sheep ranch. Solitary and sickly – Melville told friends she should have died about six times as a child” (Dunphy 2006, n.p.). If she subconsciously associated sheep with the calamities of her childhood, then this association might explain why she chose to write a dissertation that focuses so intently on the destructive power of sheep flocks. I neither claim that she was aware of any internal bias against sheep nor that she was anything but scrupulously honest in her research. Neither am I insinuating that



anything about Melville's early personal history with sheep necessarily invalidates her research. The notion I do entertain is that her positionality toward sheep might have created a confirmation bias throughout her research process.<sup>13</sup> To Melville, the landscape she found in archival documents *appeared* as if it had been overgrazed by sheep.

In his review of *A Plague of Sheep* John Super finds some shortcomings in the book but nonetheless concludes that it "presents a coherent and believable picture of environmental change in the sixteenth century" (Super 1995, 1340). Is believability a criterion of a successful environmental history? An environmental history that is not believable to most people can as well or better represent actual events than one that *is believable* to most people. Furthermore, implicit in the idea that an environmental history can be believed (it is "true") is that an environmental history can be *disbelieved* (it is "false"). Besides essentially ending discussion, this creates an unnecessary dichotomy because no environmental history can be either one or the other. Despite my reservations about Melville's monocausal narrative in *A Plague of Sheep*, I find no value in labeling it believable or unbelievable. Creating a better understanding of the Valle del Mezquital's environmental history does not require that we pass such a judgment. Rather, it behooves us to regard Melville's pioneering scholarship as a starting point from which to explore new possibilities.

### **Narrative**

Colonial-era Mexican landscape descriptions almost invariably pertain to the local scale, covering a few tens of meters to a few kilometers at most. Seldom was the same location described twice at different times. The extant corpus of landscape descriptions represents a chronicle of environmental change. Because this chronicle's space-time coverage is far from complete it can only yield general statements about the spatio-temporal trends of environmental change. For instance, the abrupt appearance of stony pavements and

barrancas in the historical record would indicate that a process of soil erosion had begun. Similarly, dry creek beds and waterholes would suggest that either environmental or climatic aridity increased. Only rarely does the chronicle attempt to explain the origin of landscape features, and even then the explanations should be considered only possibilities. But what is even more difficult to determine are the particular scales at which environmental changes occurred within a three-dimensional landscape. Soil erosion can serve here as an example. If soil erosion in the study area only occurred on hillslopes, then sedimentation must have benefitted downslope locations. If soil erosion occurred in all of the study area's elevational zones, then another region must have gained the sediment (Friedel 1994; Martínez-Fernández and Esteve 2005). It is important for an historical study to explicitly state the scales of environmental change under investigation in order to prevent unnecessary confusion over the interpretation of those changes (Brown and Allen 1989). Mapping the study area's chronicled biophysical elements in specific space-time frames provides such explicit scales of analysis.

Recognition of varying scales of environmental change helps to identify potential causal relationships between and among an area's biophysical phenomena. Typically, scholars do not dispute the broadest patterns of spatio-temporal environmental changes the chronicle of landscape descriptions preserves. Differences among researchers arise in the interpretation of the *meaning* of environmental changes, which is to say which *processes* were involved. As mentioned above, Melville (1994) suggests that in the last two decades of the sixteenth century an increasing number of references to aridity in the Valle del Mezquital reflects the effects of sheep overstocking on the region's hydrological regime. Endfield and O'Hara (1999a) acknowledge the aridity signal within the historical chronicle but they suggest it instead reflects the effects of drought conditions. Both explanations identify variables –

sheep pastoralism and climatic drying – that fit well into a cause-and-effect process to increase aridity (Stocking 1987, 50). But neither variable is likely a conclusive or complete explanation for the aridity, nor should they be viewed as mutually exclusive (Blaikie and Brookfield 1987, 27). This is because the study of historical environmental changes relies on induction. Inductive relationships are known through experience, but a cumulation of singular experiences cannot sum to any universal statement held to be true in all times and places. Weighing the importance of sheep pastoralism and climatic drying, if a weighing must be made, leads to what Popper (1959, 28) calls “the problem of induction.” Despite the inconclusive roles of possible “cause” variables in cause-and-effect processes, Butzer (2005, 1795) recommends induction as the logic system for studying historical environmental change.

A coherent historical narrative of environmental change allows meaning to emerge from inductive interpretations of the historical chronicle. The formerly dominant methodology of Western history maintained that it is the historian’s task to impartially present the facts and let them speak for themselves. Throughout this process the researcher is presumed to be innocently disconnected from the implicated meaning of the facts (Munslow 2006, 12; Smith 1999, 30-1). The postmodernist assault on this approach to history emphasizes the multiplicity of possible interpretations of a single historical event or process. History then becomes an iterative process of reinterpretation in light of new evidences, inductions, and narratives, usually in that order (Dennis 1991, 281). Uncertainty, then, can rarely be eliminated because a revision to a widely accepted narrative may lie just one newly unearthed document or novel perspective away.

Why weave a chronicle into a narrative in the first place? Environmental historian William Cronon (1992) has written at length on this question. He believes that formulating a

narrative, which he also calls a story, allows the meaningful connection of a chronicle's discrete events.<sup>14</sup> The story's plot, often either whiggish or declensionist, allows us to better understand the significance of the past. Cronon (1992, 1349) argues that the historical uncertainty that postmodernism demands of us must then be acknowledged because in the act of constructing story plotlines "we move beyond nature and into the intensely human realm of value."<sup>15</sup> Barthes (1977, 79, 124) argues that narratives abound in all human societies because what they are is language. Even more fundamentally, our brains seem to be hard-wired to create narratives from fragmentary data (Linden 2007, 225-6). Narrative is particularly inescapable if we want to describe changes over time, even in analytical quantitative research (Seigel 2004, 435). Choices must continually be made about which data are relevant, and we then construct a familiar narrative based upon those data (Carr 2008, 22).

What is familiar to each of us – and what we *feel to know* – depends upon the many aspects of our own biographies (Burton 2008). Furthermore, in the increasingly reductionist atmosphere of academia we tend to become intellectually myopic within our disciplinary boundaries, which influences us in the narratives we construct, support, and object to. The causes of environmental degradation, Little (1994, 213) observes, seems to be especially prone to spark debates that fall along ideological lines. The dynamic and multi-causal mechanisms of environmental degradation likely create an intellectual milieu highly susceptible to contention. Another factor that leads to contention may be impingements upon researcher impartiality. A researcher who identifies a cause of degradation may be challenged by another researcher who is, perhaps out of principle alone, that cause's pertinacious defender. This may be more common when vested interests are at stake, such as research grants and professional reputations.

## Conclusion

Study of the historical landscape transformations of colonial Mexico is largely dependent upon the various documentary collections of local and national archives. As already mentioned, these documents provide specific space-time snapshots of the environment, which together form a chronicle of environmental changes for a given area. How to best turn such chronicles into narratives of environmental change has led to important questions of methodology. Methodological decisions determine the sweep of the narrative and consequently how we understand processes of environmental change. A poorly devised methodology that misrepresents these processes might then lead to the misformulation of contemporary development policies (Sluyter 2002, 4). Well-informed land-use policies vis-à-vis agropastoralism are of critical importance in semi-arid Mexico as the country's per-capita consumption of meat and milk increases in response to rising personal incomes and urbanization (Ehui *et al.* 1998; Gill 1999; Delgado 2003). A broader implication of this dissertation may be improved theorization of landscape change in semi-arid Mexico as a means to ensure food security.

One's positionality is best known through reflexivity. The multi-disciplinary approach to environmental history that Butzer espouses should make the positionality of each member of the research group less determinant of the sweep of the final narrative. Yet objectivity may still be comprised at the group level, for example by pressures from funding sources. Nevertheless, my consideration of Butzer and Melville's positionalities as solo researchers has yielded these generalities that may represent fundamental reasons for their divergent views: 1) Seemingly out of principle alone were some historical geographers hostile to Melville's narrative that absolved indigenous land-use as an explanation for today's degraded landscapes and appeared to reinforce the "pristine myth." 2) Butzer's conception

of environmental history predisposes him to be a tough critic of Melville's scholarship. 3) Melville may have begun her research into the origins of the Valle del Mezquital's environmental degradation with a confirmation bias toward sheep overstocking.

In the next chapter, I address the methodological concerns that arise from using archival data to study the environmental impacts of New Spain's livestock ecology. The chapter opens with a discussion covering the three most pressing methodological concerns in this regard: the preservation rate of the extant land grants; estancia morphology; and average stocking rates (which together with estancia size yields grazing densities, or the number of head per unit area). I discuss how previous scholars approach these concerns and how this dissertation addresses each of them. I then compare the results of my archival research with Melville's. I do this because Melville defines a sub-area of the Valle del Mezquital that corresponds to my own study area (correspondence in terms of containing the same colonial-era administrative pueblos). The results of my archival research suggest that many of the estancias Melville infers – and then relies upon to propel her degradation narrative – may be unwarranted reifications. I anatomize her methodology in order to understand how we reach different conclusions based upon the same historical documents. I then discuss Sluyter's cartographic approach to methodological obstacles and how his mapping technique informs my own. The chapter considers agricultural semi-terrace abandonment as a possible mechanism of environmental change. Lastly, I review the rangeland ecology literature in order to understand how the introduction of sheep may have transformed the environment of semi-arid highland Mexico.

If I intend to study the environmental transformations that result when people introduce sheep into a region, then it is profitable to establish a tentative biophysical baseline by which to identify and understand those transformations. Chapters 3 and 4

attempt to provide this baseline by outlining the study area's natural and pre-Hispanic inhabited environments, respectively. Some of the elements I discuss in chapter 3 are soils, hydrology, topography, and the climatic regime. The climatic regime reflects the dominant pattern of global and regional-scale oceanic and atmospheric circulations. Long-term climatic averages affect the landscape-scale distribution of soil classes, hydrology, floristics, and so forth. Topography helps to mediate climate and the landscape-scale elements, for instance in terms of vegetative elevational zonation, aspect (and insolation), and soil moisture. Throughout most of Earth's history these elements have acted synergistically and unceasingly to rework every landscape. In chapter 4, I trace the cultural, political, and demographic changes within the study area beginning with human occupation (roughly 12,000 BP) through the Late Postclassic Period (1350-1521CE). I describe the importance of the cultivated plants maguey and nopal within the indigenous cultural ecology. I also outline how native peoples modified their environment with emphasis placed on semi-terrace agriculture. The chapter is largely informed by multiple lines of evidence including sixteenth-century Spanish accounts of indigenous cultural ecology and modern investigations into the area's archaeology and palynology.

In chapter 5, I leverage the relatively small size of my study area to map many of its estancias to a relatively precise degree. A time-series of maps reveals the spatio-temporal development of the study area's estancia complex. As a unique contribution to the literature, I employ a Geographic Information System (GIS) to analyze the various characteristics of estancia location. This spatial analysis emphasizes the reality of a three-dimensional landscape by considering the aspect, slope, and elevation of each estancia. A textual analysis of the extant landscape descriptions finds spatio-temporal patterns among hydrology, floristics, soil erosion, and estancia location.

This dissertation is based primarily upon published and unpublished primary source materials.<sup>16</sup> The Archivo General de la Nación (AGN) in Mexico City houses various archival collections that I draw upon to reconstruct the study area's early-colonial cultural and biophysical landscapes. The AGN's Mapoteca holds maps of the study area that have been useful to identify some extinct toponyms that archival documents preserve. I conducted extensive field work in order to locate the biophysical and cultural landscape features that appear in archival sources.<sup>17</sup> In the field I used a handheld GPS device to record the locations of various landscape features, such as watering holes and lime kilns, to facilitate more accurate mapping of estancias.

#### End Notes

1. Some of these scholars include Lesley B. Simpson, Woodrow W. Borah, Sherburne F. Cook, and of course Carl O. Sauer and his students.
2. For over a century untreated storm runoff and sewage water has flowed northward from the Basin of Mexico into the Valle del Mezquital. Through a system of canals, tunnels, and reservoirs this water irrigates roughly 90,000 ha. of the region's farmland. No other region in the world is irrigated by more wastewater (Pérez León and Biswas 1997). Irrigation increases soil organic matter with positive effects for crop production (Ramirez Fuentes *et al.* 2002). But this untreated water also increases the amount of heavy metals (Orgeta-Larrocea *et al.* 2001) and fecal bacteria in the soil, which threatens the health of the region's inhabitants (Cifuentes *et al.* 1993; Gallegos *et al.* 1999). The water used for irrigation, and that which leaks from unlined canals, has recharged the Tula River Valley's aquifer to such an extent as to make it a potential future supplier of water to Mexico City (Jimenez and Chávez 2004).
3. Trimble (1992) observes that historical geographers still do not take full advantage of geography's human-physical interface.
4. Hughes (2008) recognizes that environmental historians ought to become more comfortable and skilled at drawing scientific data into their research. He believes this will position environmental historians to occupy an important niche between Snow's "two cultures."
5. Some of Butzer's biographical information was obtained from his Website: <https://webpace.utexas.edu/butzerkw/www>



6. The various qualities of environmental resources with which colonizers must familiarize themselves, including climatic averages, are what Rockman (2003) terms “limitational knowledge.” She suggests this knowledge may come only after a generation of settlement.
7. Yet as Rose (1997) points out, reflexivity may at times fail to provide adequate self-understanding.
8. The myth persists within the public imagination as well as postcolonial development models (Sluyter 1999).
9. O’Hara *et al.*’s (2003) article in *Nature* continues to be cited as support for widespread pre-Hispanic landscape degradation (see for example Redman 1999, 147; Gill 2000, 280; Montgomery 2007, 77).
10. O’Hara *et al.* (1993) cite Melville’s (1990, 49) article that contains this passage that clearly indicates that Melville was not perpetuating the pristine myth: “I suggest that truncation of the A horizons under the intensive indigenous systems of agriculture continued [from 1000 CE] up to the late 1570s.”
11. At this point it is interesting to note that in his review of the literature published from 1992-1995 on “Columbian encounters” Axtell (1995) apparently finds no conflict between Melville’s work and that of the historical geographers who contributed to the special issue of the *Annals*.
12. Malin (1953) cautions that seeking to confirm one’s frame of reference in this manner seldom yields an accurate representation of the past.
13. As I discuss in the next chapter, a peculiarity of Melville’s (1994) study is her inference of 52.7 percent (455 of 862) of the Valle del Mezquital’s estancias from archival sources other than AGN-Mercedes. Sluyter’s research in Veracruz indicates that for his study area far fewer grants are missing, and Melville’s many inferred estancias for the Valle del Mezquital may be unwarranted (Sluyter 2002).
14. Some English-speaking historians underscore the relatedness of “history” and “story” by forming the word “(hi)story” (Berkhofer 2008, 51).
15. Refer to Munslow (2006) for a more in-depth discussion of how postmodernism has influenced current historical practices.
16. Paso y Troncoso (1905 and 1939-1940) has published the various and invaluable colonial-era accounts of the societies and landscapes of New Spain.
17. I conducted archival and field research in summer 2006, spring 2007, and summer 2007.

## CHAPTER 2: METHODOLOGICAL CONSIDERATIONS

### Introduction

Historio-geographical studies of landscape changes in New Spain during the Early Colonial Period often draw upon the vast archival collections in Mexico City's Archivo General de la Nación (hereafter AGN). At the AGN I located and transcribed pertinent land-holding documents for the study area. I relied upon two archival collections in particular: *the ramo de mercedes* and *ramo de tierras* (hereafter AGN-Mercedes and AGN-Tierras, respectively).<sup>1,2</sup> A merced is a land grant document that formed the primary tool for the Spanish Crown to divide and distribute land in New Spain. Collectively, the mercedes provided the spatial organization and administration for the expanding colony (Jaeger 1982, 44). The AGN houses roughly 10,000 mercedes in 83 volumes dating from 1542-1643CE. Although Mexico City's city council had issued mercedes prior to 1542, it is in this year that the extant record begins with mercedes thereafter being systematically awarded by New Spain's first viceroy, Antonio de Mendoza, in the name of the Spanish Crown. After 1542 some temporal gaps occur during which few or no mercedes exist, and this has led to questions about the completeness of the extant collection (see Simpson 1952; Melville 1994; Sluyter 1997).

The vast majority of the study area's mercedes grant one or more of the following land-uses: a sheep ranch, legally 776 ha (*sitio de estancia para ganado menor*, the grantee is an *estanciero*); a plot of farmland, legally 43 ha (*caballería*); and a lime kiln (*sitio de calera*). Minimally, a merced describes the land-use granted, the grantee's name, the nearest principal town (*cabecera*), the calendar date of the award, and a description of the granted land's location. A locational description sometimes includes the names of adjacent landholders, toponyms of nearby landscape features and towns, and so on. The specificity and amount of locational details varies widely among the mercedes. The references to

biophysical phenomena in particular can be used to model spatio-temporal ecological changes (Butzer and Butzer 1995; Sluyter 1997 and 1998). The *tierras* are land litigation documents that span the entire colonial period. Unlike the *mercedes*, they do not have a formulaic structure and so there is great variance in each record's content and usefulness for historical environmental reconstruction. A potential methodological problem that arises from heavy reliance on the *tierras* is that an agriculturalist may have exaggerated grievances against pastoralists as well as the condition of the land in question (Endfield and O'Hara 1999b, 392).

Andrew Sluyter provides the most rigorous study of methodological issues concerning the use of *mercedes* to reconstruct an early-colonial Mexican agropastoral complex. He outlines three methodological concerns inherent in the *mercedes* that scholars would do well to acknowledge. In this chapter's first section I review his three methodological concerns and their relevance for the present study. First, the preservation rate of the extant *mercedes* is unknown. Second, awarded lands likely deviated from the legally prescribed 776 ha for sheep *estancias* and 43 ha for *caballerías*. Third, stocking rates varied through space and time. Sluyter (2002, 97) cautions that, "Without resolution, all three issues compromise any analysis." In the second section, I discuss a sub-area of the Valle del Mezquital that Elinor Melville termed the "Southern Plain." This area is congruent with my study area in terms of principal towns. I sought this congruence when I defined my study area in order to compare my data collection and analysis with Melville's for the same area. In the third section, I anatomize Melville's methodology with a particular focus on her possible reification of *estancias* from archival fragments. I base this deconstruction on the insights of previous scholarship as well as my own archival research. In the fourth section, I consider the cartographic technique that Sluyter employs to overcome methodological

issues. While reading the mercedes I gradually developed a heightened perception of agricultural terrace abandonment as an additional possible mechanism for early-colonial soil erosion. In the fifth section, I underscore the importance of perception when studying environmental transformations. Finally, I discuss how the findings of rangeland ecology can inform and enhance historical rangeland studies such as this one.

### **Three Key Methodological Concerns**

#### **1. Preservation Rate of AGN-Mercedes**

There is a scholarly consensus that some proportion of mercedes are no longer preserved in any source. Within AGN-Mercedes, some years are known to be only partially preserved and some others completely missing (Sluyter 2002, 98). This has led to decades of speculation concerning the completeness of AGN-Mercedes. Simpson (1952) wrote the seminal work on this methodological problem. He interpolated among the years with weakest and greatest coverage to calculate that about 75 percent of all the AGN's mercedes for sheep estancias are extant. Some later researchers have applied Simpson's estimate to their own study areas (e.g. Barrett 1970). Still others have calculated their own estimations of the extant record's completeness that are particular to their respective study areas. For instance, Prem's (1992a) interpolation of mercedes in the upper Río Atoyac drainage basin of northwest Puebla for the period 1587-1620 leads him to conclude that only 60 percent of all the mercedes for this region are preserved in AGN-Mercedes. When only considering those mercedes awarded before 1587, this figure plunges to 25 percent. Sluyter (2002, 100-1) believes that such an interpolative method fails to reflect the inter-annual variations in the number of mercedes awarded. Butzer and Butzer (1997) believe that for the Bajío the preservation rate of mercedes is rather high, with fewer than 30 percent missing from AGN-Mercedes. They do not elaborate on how they arrive at that percentage.

For my study area I have located in AGN-Mercedes 51 mercedes for estancias, caballerías, and caleras. I have located an additional 16 such mercedes preserved in archival collections outside AGN-Mercedes (Appendix A). Nine of these 16 date to years that AGN-Mercedes has no records.<sup>3</sup> Of the 67 total mercedes, 23.9 percent derive from outside AGN-Mercedes (16 of 67). This corresponds well with the Butzers' (1997) estimate for the Bajío. Focusing on just the 44 mercedes that granted estancias, 35 derive from AGN-Mercedes and nine from other sources.<sup>4</sup> So of these 44 mercedes, 20.5 percent derive from sources other than AGN-Mercedes (nine of 44). The total number of estancias for which I have found mercedes is 47.

It would be folly to conclude that because AGN-Mercedes preserves 51 of the 67 extant mercedes for the study area, that AGN-Mercedes' preservation rate is 76.1 percent. Scholars agree that a certain number of mercedes are no longer preserved in any source. This means that the preservation rate of AGN-Mercedes for the study area is very likely lower than 76.1 percent. Pragmatic identification of these "missing" mercedes has become a methodological sticking point between Melville and Sluyter. I return to this matter subsequently.

## 2. Estancia Morphology

A second methodological concern for scholars is that estancias had irregular shapes and sizes. Legally, an estancia was to be square with its sides aligned north-south and east-west. A caballería was to be rectangular with its length twice its width, and also with its sides aligned to the cardinal directions. As mentioned above, a sheep estancia's spatial extent was to be 776 ha and a caballería's 43 ha (Galván 1868, 161-3). Any variation in shape led to a variation in size. Dusenberry (1963, 98-9) recognizes that the widespread use of the metes-and-bounds system of property delimitation effectively negated the legally prescribed shapes

and sizes of granted land. Compounding the variations among properties were inaccurate measurement techniques (von Wobeser 1983, 23) as well as the simultaneous use of the *legua común* (4.2 km) and *legua legal* (5.5 km) as measurement units (Chardon 1980, 138). Shape was also distorted when the estancieros laid claim over ungranted land between estancias (Chevalier 1963, 109). Caballerías were particularly prone to swell beyond the prescribed 43 ha because uncultivable land within a caballería did not contribute towards the total 43 ha. Maps that accompany litigation records can be helpful to understand how estancias may have varied from their specifications in the mercedes. However, sometimes landowners settled disputes among themselves without resorting to costly surveying and litigation (Chevalier 1963, 271). Such settlements would have left few, if any, archival traces.

An occasional variation in shape resulted from intentionally circular estancias, such as those Aguilar-Robledo (2003, 95) identified in the Huasteca. Sluyter (2002, 98) believes these were rare because the Spanish authorities clearly prescribed estancias to be square. Nickel (1978, 70-1) holds a different view than Sluyter. He believes that the circular estancias he found in archival sources for the Valle de Ozumba, Puebla signal the *intent* of early ordinances to grant circular estancias. Yet in Puebla and elsewhere in New Spain those precocious ordinances were soon superseded by unambiguous legislation promoting square estancias. From an administrative perspective, square estancias would have been preferable because of the tendency for circular estancias to result in litigation over the vast amount of un-awarded land that necessarily separated property lines.

Two forces probably interacted to maintain estancia sizes near what the Crown prescribed. The first was each estanciero's strong desire not to have less than the full amount of land to which he or she was entitled. This force prevented any estancia from being undersized. The second force was the neighborly policing that prevented excessively

over-sized estancias. The outcome of these countervailing forces probably meant that few estancias were smaller than the legally prescribed size, and the estancias with few or no adjacent neighboring estancias had the opportunity to be greatly exceed the spatial limit of their titles. Since it would have been rarer for estancias to be undersized than at least the legal size, and oversized estancias were possible only in the absence of neighbors, then the average estancia size within a given region was probably somewhat but not terribly much larger than the legal size limit.

The real and important variations in the size and shape of granted land within the study area cannot be known. Nor were such variations clear even in the Early Colonial Period, if the vast amount of extant boundary litigation from the time is any indication. Although the existence of circular estancias cannot be definitively ruled out for any part of New Spain, there is no indication that circular estancias existed within the study area. The only direct reference to estancia shape that I have found is for an estancia and four caballerías granted in 1606. The merced was contested and the ensuing legal documents include a small sketch of the geometric relationships of the land parcels in question. The sketch renders the estancia square-shaped with two caballerías aligned along the northern side and two along the western side. Both parties agreed that this was an acceptable arrangement.<sup>5</sup>

### 3. Stocking Rates

The question of missing mercedes becomes more than an arcane academic matter for Melville (1994). Her thesis of sheep overstocking as the proximate cause of severe soil erosion in the Valle del Mezquital during the last two decades of the sixteenth century ultimately relies upon her calculations of sheep grazing densities. In turn, the grazing densities hinge upon the stocking rates (number of head per estancia) and the number of

estancias. Sluyter (2002) believes that the fundamental reason for why the Butzers disagree with Melville's degradation narrative are her high stocking rates. After the 1560s each merced for a sheep estancia stipulated that it must be stocked with a minimum of 2,000 head, and it is this figure that the Butzers use in their calculation of grazing densities in the Bajío (Butzer and Butzer 1993, 103). This is either because they interpret that clause to mean that 2,000 head was the legal maximum stocking rate or they merely want to err on the side of caution and not infer what any higher average stocking rates might actually have been. Although Melville interprets 2,000 head as the legal maximum (Melville 1994, 137, 154) she infers much higher average stocking rates in her calculation of sheep grazing densities. She bases these higher rates upon a census taken in the 1570s in the Valle del Mezquital's Huichiapan and Alfaxayuca Valleys as well as the testimonies of Indian plaintiffs preserved in AGN-Tierras (Melville, 1983, 173-4). From these sources for the 1570s, then, Melville infers an average stocking rate of 10,000 head per estancia, a figure five times higher than the Butzers employ (Melville 1994, 83).

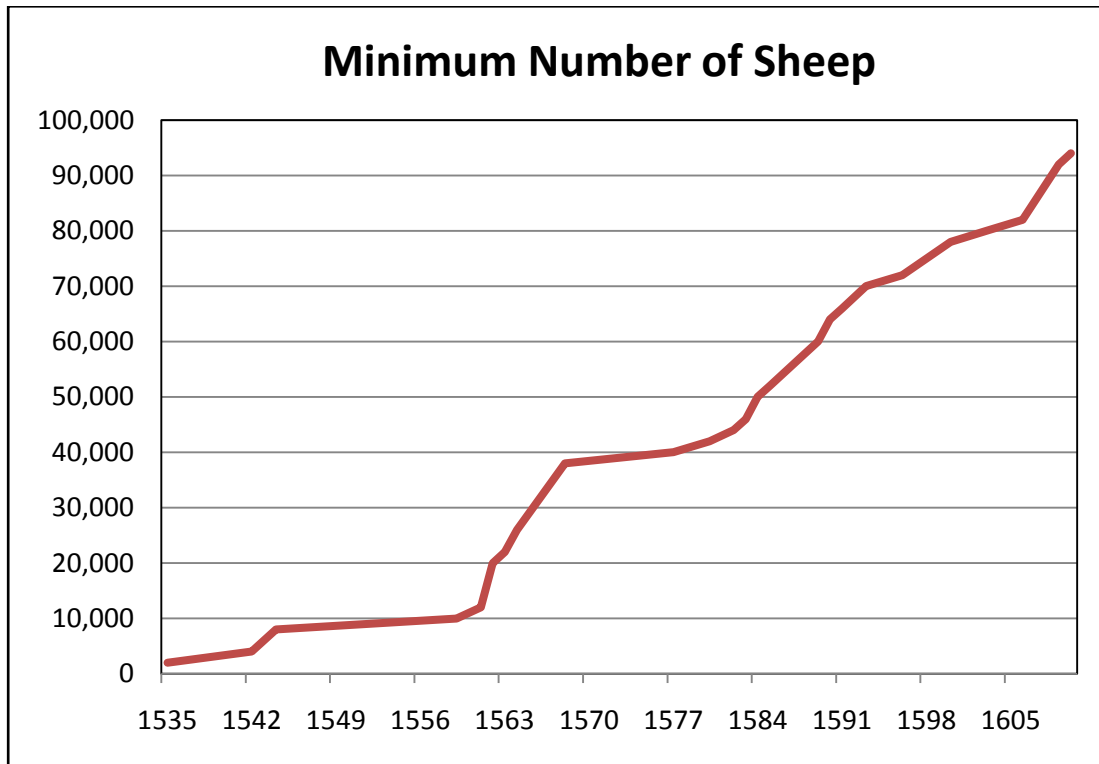
For my study area I have found two direct references to stocking rates. In 1576, the natives of Tuzantlalpa reported to the Viceroy that a local estancia was stocked with 20,000 sheep.<sup>6</sup> In 1580, the natives of Jilotzingo, a pueblo two kilometers southeast of Hueycoxotla, brought litigation against the Hueycoxotla natives. The litigation was intended to persuade the Viceroy not to award the Hueycoxotla natives another sheep estancia. The Jilotzingo natives feared that another estancia in the area would increase damage to their sementeras. Jilotzingo's encomendero, Martin Vasques, also opposed the additional estancia on the grounds that there were already too many sheep in the area. Vasques testified that the 12 surrounding estancias had 120,000 cumulative head of sheep, or an average of 10,000 head per estancia.<sup>7</sup> The veracity of both the reports from Tuzantlalpa and



Jilotzingo may be dubious considering the litigious context in which the testimony was given (Sluyter 1998, 515; Endfield and O'Hara 1999b, 391). However, the stocking rate of 10,000 head per estancia does support Melville's figure for around 1580.

Precise stocking rates can never be known. It may be best to consider stocking rates and grazing densities in terms of probable range limits. The testimony that recounts 10,000 and 20,000 head per estancia provides probable maximum limits on stocking rates. The lowest limit on stocking rates would be 2,000 head per estancia, the number of head required by law to secure the grant. Within this 2,000-20,000 head range, estancias that had few or no neighboring estancias would likely have had stocking rates closer to the upper range limit. Crowded, clustered estancias would be expected to have had more modest stocking rates, far fewer than 20,000. In addition to estancia size, range quality and management practices would have helped determine stocking rates. Because stocking rates likely varied on every estancia on a yearly basis, as well as in recognition that a certain number of mercedes are likely missing, it is only possible to calculate a *minimum* number of sheep in the study area for a given year. This number is the product of the legal minimum of 2,000 head per estancia multiplied by the number of estancias that can be traced back to extant mercedes (Figure 2.1). I take this conservative approach because the two references to stocking rates I have found are archival fragments that I am hesitant to elevate and apply as "default assignment" values to all the estancias (McClelland *et al.* 1986, 29-30; Barnett 1997, 148). The minimum number of head of sheep within the study area at the end of the granting process is 94,000. The first Mexican livestock census was taken in 1902. In this year the municipalities within and near the study area – Hueyapoxtla, Tequixquiac, Atotonilco, Tizayuca, Tolcayuca, and Zumpango – cumulatively had only 12,819 head (*Estadística Ganadera de la República* 1903). The steep drop in sheep numbers between around 1610

and 1902, along with archival references to soil erosion and dessication beginning to appear in the 1580s, suggests that environmental deterioration began in the sixteenth century's last quarter (Tables E.2-E.5). Because I do not strictly define the study area spatially, as well as the fact that sheep were not immured on estancias, I do not calculate grazing densities.



**Figure 2.1.** Minimum number of sheep in the study area

### **The "Southern Plain"**

My study area encompasses the same cabeceras as the southeastern portion of the Valle del Mezquital that Melville terms the "Southern Plain." The primary importance of the Southern Plain in this dissertation is as a spatial device with which to deconstruct Melville's land degradation narrative. By mapping the Southern Plain's boundary in a GIS and then mapping all nearby estancias, I can determine the spatial extent of the area's ranchland.

Melville's Southern Plain encompasses the modern municipalities of Hueypoxtla, Apaxco, and Tequixquiac. All of these municipalities are in northeastern Mexico state. Melville (1983, 40) provides their combined area as 483 km<sup>2</sup>. She arrives at this figure because it represents the sum of the three municipalities' surface areas as listed in the 1970 Mexican census (Dirección General de Estadística 1971, 3-5). However, the census' map of these municipalities bears only a weak resemblance to Melville's map of the Southern Plain (Figures 2.2a and b). This seems to be because Melville heavily generalizes the municipality borders. Yet there are two reasons why this generalization has little bearing upon her conclusions. First, Melville's map of the Southern Plain only needs to encompass specific early-colonial cabeceras, which the three modern municipal boundaries permit. Second, Melville only uses the municipalities' spatial extent in order to calculate grazing densities. In other words, how Melville depicts municipal boundaries, whether precise or generalized, does not affect her use of 483 km<sup>2</sup> as the surface area for the colonial-era cabeceras' jurisdictions.

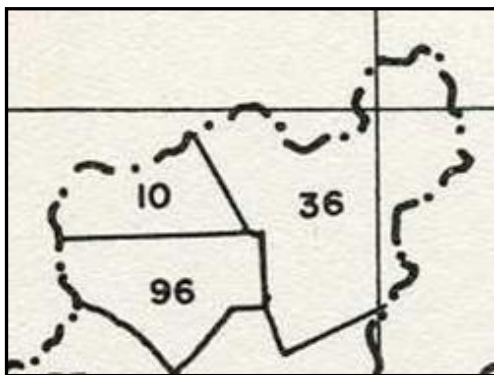


Figure 2.2a.



Figure 2.2b.

**Figure 2.2a.** The municipalities Hueypoxtla (36), Apaxco (10), and Tequixquiac (96) in Mexico state (Dirección General de Estadística 1971, n.p.). **Figure 2.2b.** Melville's (1994, 26) depiction of the Southern Plain that she bases upon the municipalities in Figure 2.2a.

A problem that *does* arise from Melville's reliance upon modern municipal boundaries, however, is that the spatial extent of the three municipalities is incongruent with the spatial extent of the early-colonial cabecera's sixteenth-century jurisdictions. This incongruity arises because Mexico's modern municipalities do not mirror sixteenth-century cabecera jurisdictions. In fact, the boundaries (and so also surface areas) of Mexico's municipalities regularly change, and there is no particular significance in their 1970 arrangement that Melville relies upon.<sup>8</sup> In her dissertation, Melville (1983, 40) acknowledges but does not resolve this problem. She declares, "The territorial extent of the areas and subareas has been taken to be coterminous with the land under jurisdiction of the cabeceras located within their borders." In *A Plague of Sheep* Melville (1994, 25) provides a statement similar to the one in her dissertation, but now fails to mention the methodological problem that modern municipality boundaries and the cabecera jurisdictions are spatially incongruent. She writes, "The final geographic boundaries and extent of the sub-areas, as for the region as a whole, are taken to be coterminous with the lands under the jurisdiction of modern municipalities."

As already mentioned, the area of analysis that Melville terms the Southern Plain contains the same early-colonial cabeceras as my study area, no more and no fewer. This makes it possible for me to compare our findings and discuss the possible reasons for why our findings differ. This discourse comprises the subsequent section.

### **Estancia Reification**

A major point of departure between Melville and other researchers (see for example Butzer and Butzer 1995; Sluyter 1997; Aguilar-Robledo 2003) is her inference of multitudinous "squatters' holdings" (Melville 1983, 80). These are estancias that appear in various sixteenth-century archival sources but for which she is unable to locate extant mercedes.

She identified these estancias in wills, litigation records, references as neighboring properties in other mercedes, and so forth.<sup>9</sup> Melville's methodology requires that any reference to an estancia that cannot be traced to an extant merced must mean that the pertinent merced was either lost or never issued (hence "squatters"). In this way she ultimately infers the existence of 455 of the region's estancias, which is *more than double* the number that do have a merced (455 of 862, or 52.7 percent) (Melville 1994, 125). Melville was aware that she may inadvertently double-count an estancia that appears in different contexts in different documents. To minimize such double-counting she cross-referenced owners' names and the toponyms of nearby landmarks of all inferred estancias against all those with a merced. That she nevertheless infers so many estancias may speak to the ineffectualness of those efforts. This merits further discussion because the number of estancias in the Valle del Mezquital determines the region's grazing density, and hence is a key driver of Melville's environmental degradation narrative.

The terms that accompanied every merced forbade its sale or transfer within four years (*Recopilación* 1841, libro 4, título 12, ley 2). Grantees often ignored these terms. Young women in need of a dowry, poor widows, those who could not afford to stock their estancias, and many others found reason to almost immediately turn over their holdings to willing buyers (Chevalier 1963, 121, 135). Land speculation had become so rife that by around 1590 Viceroy Velasco conceded, "Many estancias are now in the possession of persons *who bought them from recipients of grants* made in His Majesty's name by the viceroys and governors" (quoted in Chevalier 1963, 135, emphasis added). Recent archival investigations into matters of colonial land tenure have confirmed Velasco's observation. In his study of the Miraflores Hacienda in the Huasteca, Aguilar-Robledo (2003) found that some mercedes changed ownership within a month of being awarded. Occasionally, this was

accomplished because the grantee admitted to being a front-man. One particular merced in the Huasteca was sold four times and auctioned once within 25 years. In Guanajuato's Yuriria-Salamanca area of the Bajío, Baroni Boissanas (1990) also finds that front-men would transfer mercedes to their patrons almost immediately after receiving them. In his study of the Jesuit Hacienda Santa Lucía, Konrad (1980, 51) describes the Jesuit's use of front-men as "legal maneuvering." Prem's (1988) work in Puebla uncovers that a merced awarded in 1589 had changed ownership six times in just 12 years (one person owned this merced twice, as the third and sixth owner). Barrett's (1973) analysis of the mercedes in Michoacán's Tepalcatepec Lowland reveals a similar pattern of reselling. She concludes, "That acquisition of a merced for the purpose of selling it was common in the Lowland is further underscored by the fact that only a few of the recipients are mentioned in contemporary documents as active in the area" (1973, 83-4). Most recently, in the Yuriria-Salamanca area Endfield reports that a grantee sold his merced less than a month after receiving it, and the buyer in turn resold it just eight months later. She observes that mercedes in her study area had a "particularly high turnover" rate (Endfield 2008, 56, 188 note 54).

It is clear that the frequent transfer of mercedes was common in New Spain, and it is unlikely that the Valle del Mezquital was immune to the practice. The recurrence of an estancia in archival sources but with different owners makes it difficult to identify discrete properties. The implication of this for Melville's study is that a certain number of the 455 estancias she infers – perhaps a great many – may have never existed. Within my study area I have found instances of this confusing and fluid transference of mercedes. One estancia had five owners between 1586, the year the Viceroy awarded it, and 1621.<sup>10</sup> Litigation documents concerning another merced describe the use of a local encomendero as a front-man.<sup>11</sup> Other cases exemplify the profit to be made in the land titles market. In 1584 the

Viceroy awarded Luis Bohorquez a merced for an estancia and two caballerías near Hueyoptla.<sup>12</sup> By 1610 Luis de Olibera and his wife were in possession of the two caballerías and sold them to Andres de Estrada for 650 pesos. Six months later, Andres de Estrada re-sold the caballerías for 700 pesos. The history of this merced also exemplifies how lands that had been granted together came to have multiple owners; in 1610 the estancia was owned by a person named Diego Cataño.<sup>13</sup> In the final two decades of the sixteenth century and the first decade of the seventeenth there were many mercedes in circulation and persons who were acquiring substantial estates based upon the purchase of mercedes. For example, in the area of Tuzantlalpa and Tezcatepec Bernardino de Estrada had by 1609 acquired titles to 11 estancias and 14 caballerías, many of which he had purchased sometime previously.<sup>14</sup>

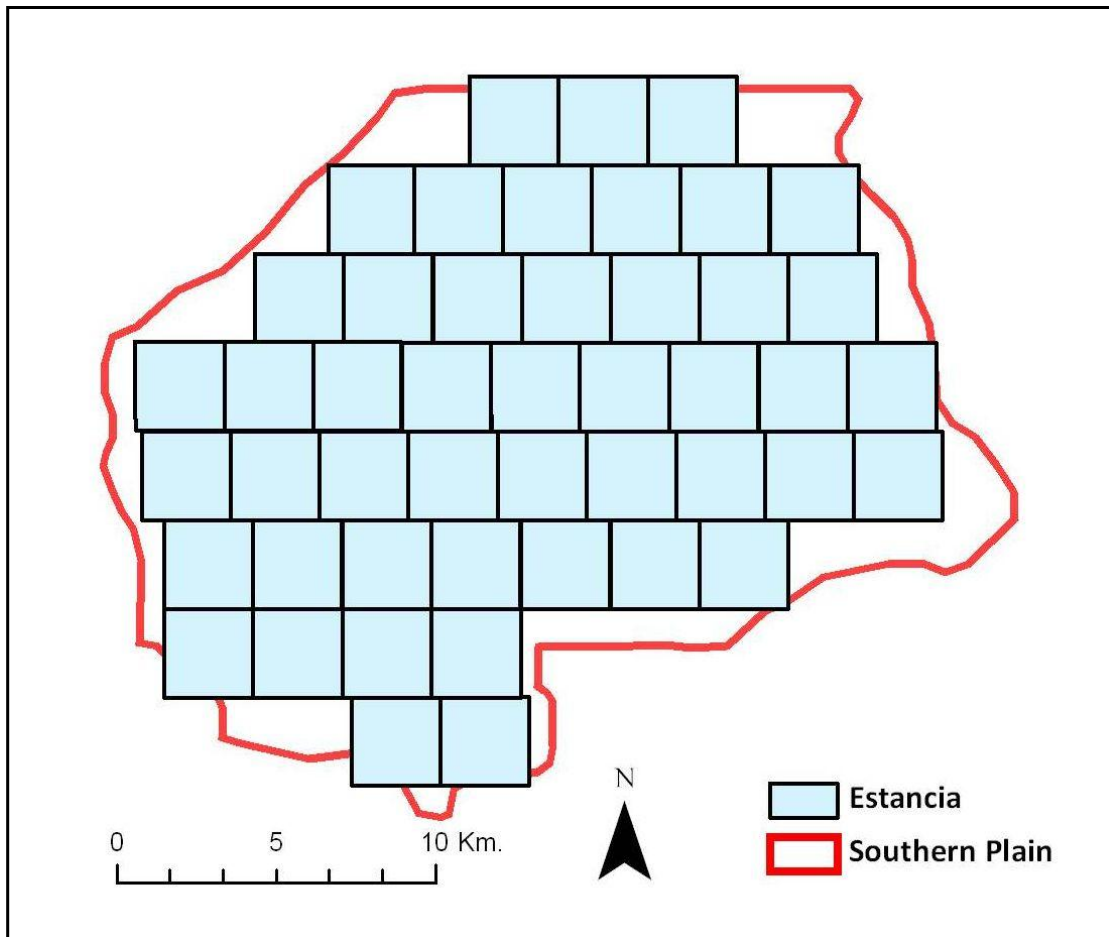
Melville's methodology presumes that toponyms were as static as the names of land title holders. However, the toponyms of landscape features were in a state of rapid flux as the Spaniards replaced Nahuatl and Otomí language names with Spanish ones. This renaming process was a spatial discourse that facilitated Spanish acquisition and compartmentalization of land (Carter 1987, 7-8.). Amid this flurry of renaming, different people may have concurrently referred to the same landscape feature by different names (Dyckerhoff 1984, 234). An example of this occurred within the study area. The pueblo of Tequixquiac lies amidst relatively flat land except for the presence of a prominent flat-topped mountain that flanks it immediately to the west, now simply called Mesa Grande. This is the only mountain that was within the town's jurisdiction to award mercedes. In 1577 the Viceroy granted an estancia near Tequixquiac, which the merced describes to reside on a large mountain named Maquechuacan.<sup>15</sup> This mountain can only be Mesa Grande. Seven years later the Viceroy awarded another estancia within Tequixquiac's jurisdiction; the merced describes the estancia to be on a large mountain named Tlatzalan.<sup>16</sup> So it appears

that both Maquechuacan and Tlaztalan were toponyms the local people used concurrently for Mesa Grande.

Even with her analysis of owner's names and toponyms Melville was aware that she still might double-count an estancia because different archival documents mention it under changing social and toponymic contexts. In her dissertation she reduced by 20 percent the number of squatters she identified for the 1580s and 1590s. She made this adjustment in acknowledgement that in those two decades many estancias had been awarded and doubtless changed ownership several times without extant documentation of the transfers (Melville 1983, 120). This is a prudent step in light of the previous discussion on mercedes transference. Melville does not, however, explain how she decided to reduce squatters by the figure 20 percent. Between her dissertation (1983) and *A Plague of Sheep* (1994) she increased that reduction from 20 to 30 percent but did not acknowledge the increase or why she made it (Melville 1994, 127).<sup>17</sup> One possible explanation is that she became increasingly aware of inadvertently double-counting the same estancia. Another explanation is that because she had identified more estancias after completing her dissertation she simply wanted to hold her calculations of the percentage of land converted to estancias and caballerías under 100 percent. For example, in *A Plague of Sheep* the Tula subarea has the highest percentage of land converted to estancias and caballerías by 1599 – 99.2 percent. If in *A Plague of Sheep* she had used her dissertation's lower reduction of 20 percent, then that percentage would have reached 102 percent.

Melville's inference of so many squatters and her seemingly arbitrary 20 and 30 percent reductions of them led her to infer a landscape that by 1599 was on the cusp of being totally converted to the Spanish land tenure system. She describes that at the century's end the Southern Plain was "completely taken over" by land grants, particularly





**Figure 2.3.** The study area's 47 estancias mapped according to Melville's conception of space as a device for which to yield sheep grazing densities

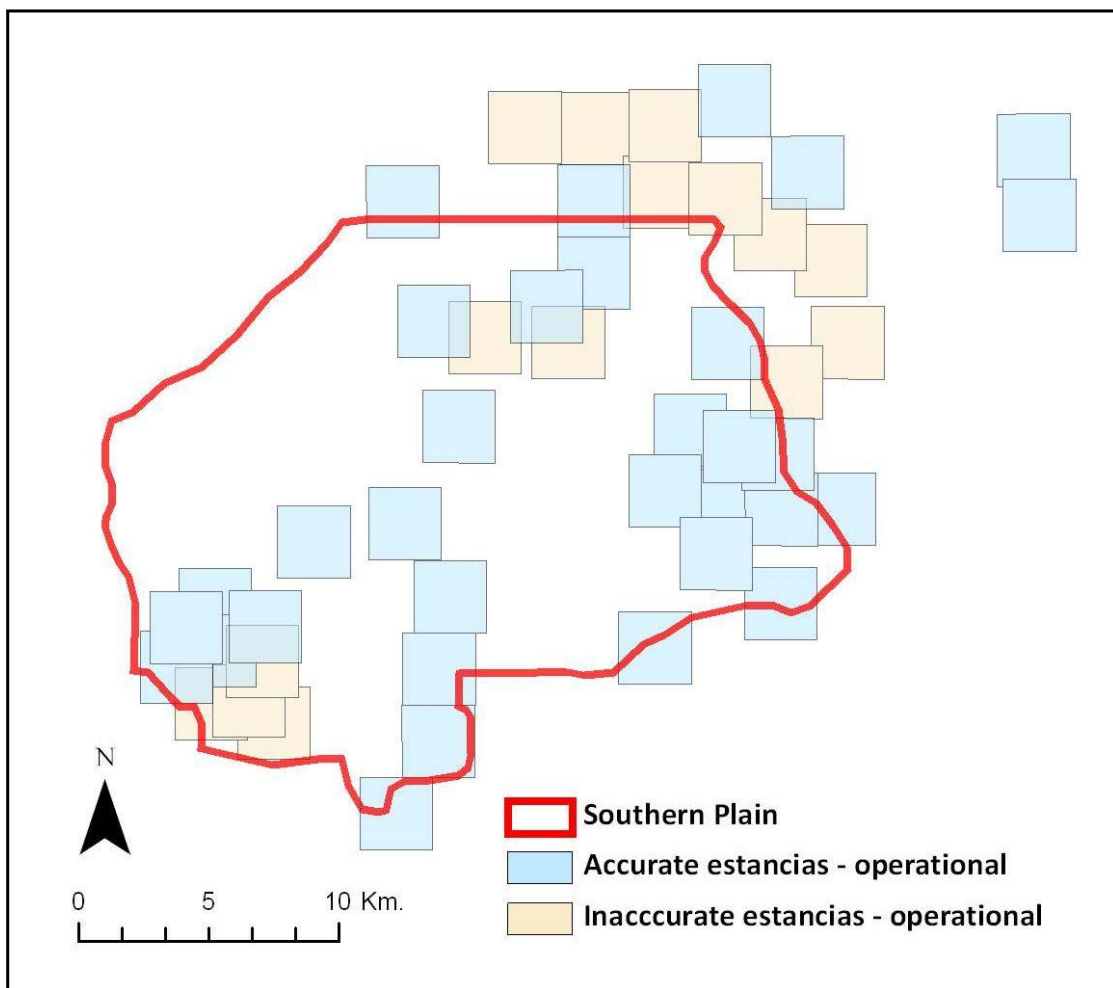
sheep estancias (Melville 1994, 146). In *A Plague of Sheep* Melville calculates that by 1599 81.6 percent of the Southern Plain's spatial extent had been converted to estancias and 10.8 percent to caballerías (92.4 percent total) (Figure 2.3; Melville 1994, 144). The 81.6 percent breaks down to 31.25 estancias with extant mercedes and 19.25 squatters (22 squatters before her 30 percent reduction for the period 1580-1599).<sup>18</sup> For this area through 1599 I have identified 36 estancias with extant mercedes, eight of which derive from sources other than AGN-Mercedes and do not appear to be forgeries (Appendix A).<sup>19</sup> The difference between how many estancias with mercedes she and I found is only 4.75. This indicates that my archival research was slightly more thorough than Melville's – an expected outcome of

researching only one section of the Valle del Mezquital rather than the entire region. Where we drastically diverge in the fruits of our archival research are with squatter estancias.

Despite the depth of my archival research, or because of it, I have identified references to only five tracts of land that I am unable to trace ownership back to an original merced.<sup>20</sup>

Like elsewhere in New Spain, land granting in the Valle del Mezquital continued past 1599 and into the first quarter of the seventeenth century. This means that I can extend Melville's methodology past 1599 to help determine if whether by that year the Southern Plain was really so thoroughly converted to the Spanish land tenure system. For this area I have located mercedes for 11 estancias and 40 caballerías awarded after 1599. Using Melville's figure of 483 km<sup>2</sup> for the surface area of the Southern Plain, these post-1599 land parcels represent 21.3 percent of the surface area (Appendix A). The addition of these parcels to Melville's 1599 figure of 92.4 percent raises her figure to 113.7 percent. Prem (1992a, 449-50) finds in his archival study area of Puebla's upper Atoyac drainage that more land may have been granted than was available in order to prevent interlopers. He also suspects that inaccurate surveying may be partly responsible. However, the impossibly high land conversion rate of 113.7 percent clearly arises from Melville's pre-1600 "squatters," many of which are probably just archival artifacts. It is also partly the result of her methodology that lacks consideration of spatiality. Each merced provides the name of the cabecera within whose political jurisdiction the Viceroy awarded it. Melville assumes that, unless explicitly stated in a merced, each tract of granted land fell entirely within the same subarea of the Valle del Mezquital as its cabecera. The problem here is that she does not draw the Mezquital's internal subareas to reflect the cabeceras' sixteenth-century jurisdictions (Melville 1994, 25). Fotheringham (1997, 88-9) observes of spatial data, "Simply reporting one 'average' set of results and ignoring any possible spatial variations in those

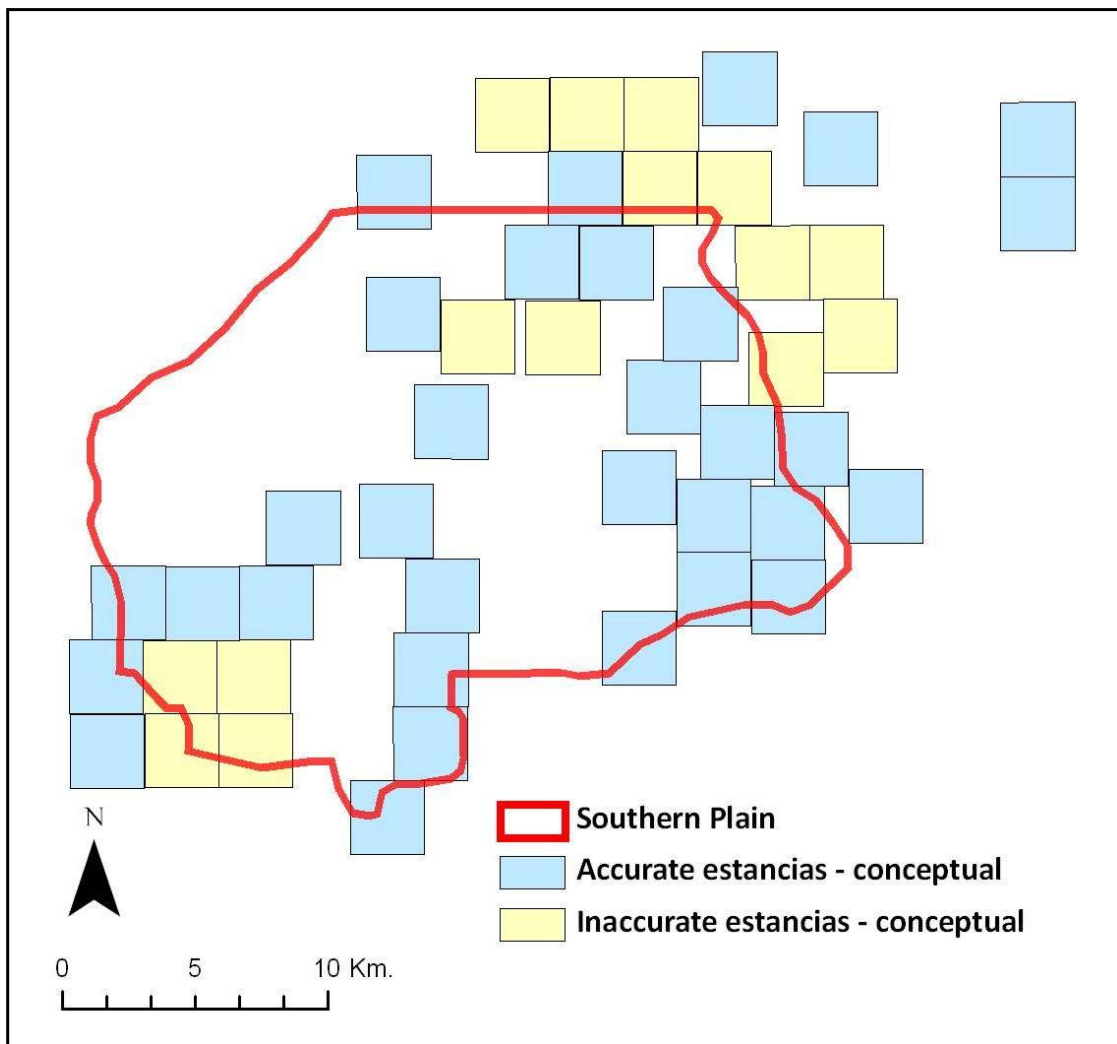
results is equivalent to reporting a mean value of spatial variation without seeing a map of the data.” Indeed, a map of the Southern Plain’s estancias casts doubt upon Melville’s land conversion rates and average grazing densities for the area. Even assuming that Melville’s boundary of the Southern Plain mirrors the cabecera’s sixteenth-century jurisdictions, what I find by mapping the estancias is that 27 out of 47 (57.4 percent) fall either partially or completely outside of the Southern Plain (Figure 2.4).



**Figure 2.4.** The study area’s 47 estancias mapped according to their operational occupation of space. Twenty seven of the 47 lie partially or entirely outside of the Southern Plain. Accurate estancias +/- 2 km locational error, inaccurate >2 km

## Conceptual and Operational Maps

For his study of land-granting in the central Veracruz lowlands Sluyter prudently adopted a cartographic approach. Recognizing the flaws in Melville's aspatial methodology, this was meant to avoid double-counting estancias. He first mapped the estancias with extant mercedes as area symbols. Only after completing that did he attempt to fit into his map the estancias he found referenced in various documents but lacked extant mercedes. Sluyter mapped the well-described estancias with a precision of  $\pm 2$  km. Using those estancias as a



**Figure 2.5.** The study area's 47 estancias with extant mercedes mapped according to Sluyter's cartographic technique that displays their conceptual occupation of space. Accurate estancias  $\pm 2$  km locational error, inaccurate  $>2$ km

geometric scaffolding he could then map the poorly described ones at a lower precision of +/- 10 km. His area symbols for estancias reflect how the properties were legally (or *conceptually*) prescribed to be laid out, square with their sides aligned with the cardinal directions (Figure 2.5; Galván 1868, 161).<sup>21</sup> Sluyter (2002, 108) explicitly states that his conceptual maps are not cadastral. His cartographic methodology led him to infer only four of the 233 estancias he mapped, or 1.7 percent (in contrast to Melville, who inferred 52.7 percent) (Sluyter 2002, 114). For his study area Sluyter (2002, 114) finds AGN-Mercedes to be 87.6 percent complete.<sup>22</sup> “Thus,” Sluyter (2002, 114) concludes, “at least for the Veracruz lowlands, ‘correcting’ for ‘lost’ mercedes is unjustified and results in spurious analyses. Few if any estancias additional to those documented seem warranted or, indeed, even possible.” But this statement is only true in relation to the unrealistically geometrical estancia framework of his conceptual maps. Conceptual maps cannot reflect how estancias regularly deviated in shape and size (Dusenberry 1963, 98-9; Gibson 1964, 276). The question I raise is can Sluyter’s conceptual map of estancias – in which some estancias are mapped only with a precision of +/- 10 km – really speak to the completeness of AGN-Mercedes? I am skeptical that it can.

Sluyter (1995, 613) believes that application of his cartographic methodology to a smaller study area will increase mapping precision because more thorough archival and field work will be possible. He anticipates that such maps could depict the *operational* framework of an area’s estancias, which is to say how they actually occupied space (their overlap, size variations, metes-and-bounds, *etc.*) (Sluyter 1995, 551, 553). For my study area, I created operational maps that depict estancia overlap, which I analyze in the next chapter (Figure 2.4). Operational maps are not necessarily more useful than conceptual maps to help estimate the completeness of AGN-Mercedes. An operational map of a particular area, with

its overlapping estancias, increases the space where more “missing” estancias would be suspected. This would in turn indicate a less complete AGN-Mercedes. Likewise, a conceptual map of the same area, with its non-overlapping estancias, would decrease the space for more suspected “missing” estancias. This would then indicate a more complete AGN-Mercedes. Indeed, it is this latter scenario that appears to explain why Sluyter judged AGN-Mercedes to be rather complete for the central Veracruz lowlands. Sluyter’s oversight in this regard may relate to what Harley (1989, 85) calls a map’s “internal power” that can make us “prisoners in its spatial matrix.”

### **Perception**

In this section I do not propose another dominant narrative for the Valle del Mezquital. Rather, I merely seek to nudge this environmental history beyond the Butzer-Melville debate by widening our perception of possible cause-and-effect landscape changes. Specifically, I explore agricultural terrace abandonment as another possible mechanism of landscape degradation. I open this section with an anecdote involving Ludwig Wittgenstein that should raise consciousness about presuming cause-and-effect. An acquaintance of the Austrian philosopher recalls, “He once greeted me with the question: ‘Why do people say that it was natural to think that the sun went round the earth rather than that the earth turned on its axis?’ I replied: ‘I suppose, because it looked as if the sun went round the earth.’ ‘Well,’ he asked, ‘What would it have looked like if it had *looked* as if the earth turned on its axis?’” (Anscombe 1959, 51). Here Wittgenstein indicts the “natural” preference of one construal of an event over the actual construal. But to recognize that there *even exists* an alternative construal to the “natural” one – unless one is inordinately imaginative – requires a new dataset or the reinterpretation of an existing one. Once these data are in hand a gestalt shift in perception may take place. A familiar example of a gestalt shift is Rubin’s familiar vase-

face illusion wherein one's visual focus can shift between a vase and the two faces it outlines (Rubin 1915; Pinker 2007).

Like Wittgenstein's anecdote, a common adherence to the easily perceived relationship between two phenomena rather than the actual one is also present in the literature on the historical causes of soil erosion in central Mexico. A useful example here is Heine's (2003) paleopedological analysis of slope soil profiles in Mexico's Puebla-Tlaxcala region, parts of which had been terraced since around 1600BCE. He writes of the period 100-650 CE, "Areas with pronounced soil erosion experienced especially large decreases in population" (2003, 242). I accept that Heine correctly identifies soil erosion in those depopulated areas. But like the gestalt shift of Rubin's vase-face illusion, the reader will usually only perceive *meaning* according to internal prejudices – did the soil erosion cause the depopulation, or vice-versa? Heine (2003, 242) continues, "In comparison, the number and location of villages in the basins, where soil erosion was not widespread, has remained relatively constant since about 600BCE." This passage again requires the reader to choose a perception – were the villages not depopulated because there was no widespread soil erosion, or vice-versa? In such passages it is often difficult to formulate a novel perception because the reader is focused on understanding the author's perception (or narrative). Heine is explicit that his perception is soil erosion led to depopulation. Heine (2003, 243) employs a rhetorical device intended to steer the reader toward his perception of events: "less people = less agriculture → shrub and forest recovery → less soil erosion." His argument's visual structure draws upon the modality (and presumed authority) of mathematics but is only supported by his perception.

As in the Puebla-Tlaxcala region, the Valle del Mezquital's southern half was a heavily terraced landscape at Conquest (see Chapter 4). An agricultural terrace is a cultural

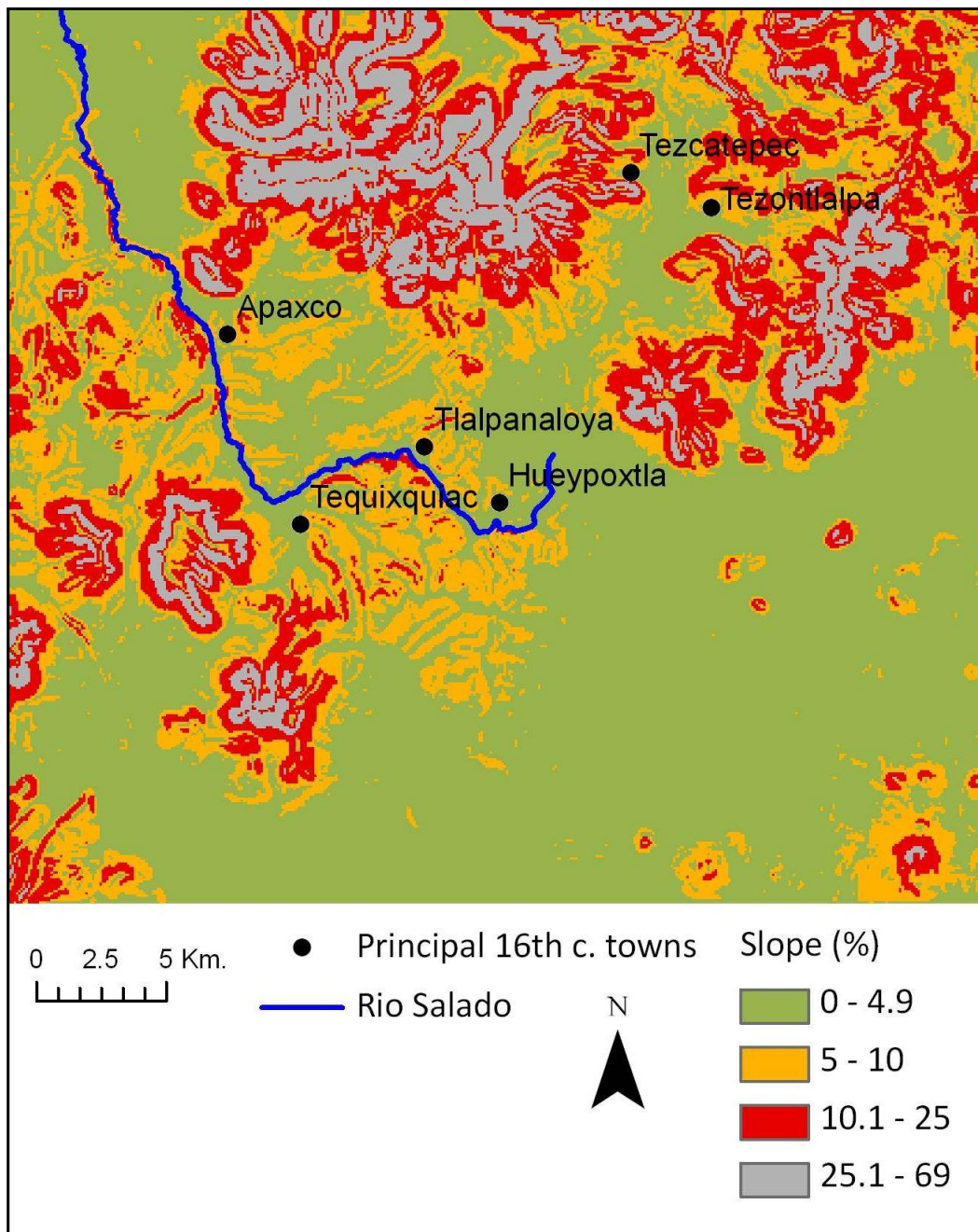
landscape feature that permits long-term crop cultivation on hillslopes by providing a more level planting surface. A level surface slows down precipitation run-off, allowing it time to infiltrate into the soil. A terrace, then, increases soil moisture and reduces soil erosion. In Mesoamerica, terrace construction was infrequent or absent where natural precipitation flow permits reliable cropping. This indicates that indigenous agriculturalists constructed terraces to increase soil moisture and reduced soil erosion was an ancillary benefit (Donkin 1979; Sanders and Murdy 1982). A rare and insightful description of agricultural terracing is preserved in a 1579 landscape description of Chilchota, Michoacán. The Spanish author describes eroded hills where in pre-Hispanic times a much larger indigenous population had constructed homes and stone-faced terraces. The author's interpretation of Chilchota's environmental history was that the terraces preceded – and were constructed on account of – the soil erosion he was viewing in 1579 (Ramos 1958, 16-7). But another perception of this landscape may better describe actual events. Every terrace has latent instability; once labor inputs cease, the bare soil is highly erodible. This is because a terrace is a form of *landesque capital*. These are high-maintenance landscape improvements that represent accumulated human capital that is available in the present (Brookfield 1984; Blaikie and Brookfield 1987). In Michoacán's Lake Pátzcuaro Basin, archaeologist Christopher Fisher and colleagues use the *landesque capital* concept to help explain the area's environmental degradation. Their work suggests that soil erosion in the pre-Hispanic era occurred around population centers and was not associated with agriculture. Their hypothesis is that landscape-wide soil erosion only occurred in the Early Colonial Period when the native population collapsed and the agricultural terraces that were in use since the Early Postclassic Period (900-1150CE) were abandoned (Fisher *et al.* 2003). Fisher (2005, 88) explains, "Intrinsic to *landesque-capital* landscapes is a degradation time clock that stops ticking when labor is pulled from the



system, because intensive features must be maintained to ensure environmental stability.” Michoacán’s contested environmental history continues to be studied (see O’Hara and Metcalfe 2004; Metcalfe and Davies 2007; Metcalfe *et al.* 2007).

The acceleration of soil erosion following the abandonment of agricultural terraces is not unique to Lake Pátzcuaro. In the 1930s W.C. Lowdermilk (1953) conducted a field reconnaissance of Old World soil erosion on behalf of the U.S. Soil Conservation Service. In Jordan, Jericho, Algeria, and Syria he found that abandonment of agricultural terraces instigated periods of soil erosion. In the 1970s and 1980s researchers found that agricultural terrace abandonment had contributed to soil erosion in Greece’s Southern Argolid region (Forbes and Koster 1976; van Andel *et al.* 1986). By the late 1980s an undergraduate-level environmental history textbook acknowledged that terraced fields are in a “metastable equilibrium state” while tended but degrade after maintenance ceases (Roberts 1989). A similar pattern emerges from locations around Latin America. In his seminal study of semi-terraces in Mexico, Robert West (1970) found that their abandonment led to sheet erosion and gully erosion within living memory.<sup>23</sup> Since then, terrace abandonment has also been correlated with soil erosion in the Basin of Mexico (Sanders *et al.* 1979, 243), Mexico’s Teotihuacán Valley (Evans 1992) and Texcoco Piedmont (Córdova and Parsons 1997), the Ecuadorian Andes (Harden 1991), and Bolivia’s Calicanto watershed (Zimmerer 1993).

But do archival records indicate that agricultural terrace abandonment led to the Valle del Mezquital’s environmental degradation? To answer this question I closely read the early-colonial land distribution documents for the study area. At Conquest (1521 CE) this area was densely populated (Gerhard 1993, 295). Semi-terraces would have occurred on many of the slopes of 5-10 degrees and to a lesser extent on the steeper slopes of 10-25 degrees (Figure 2.6; West 1970). By 1570 in central Mexico contemporary estimates



**Figure 2.6.** Slope classes of the study area

were that the native mortality rate exceeded 50 percent and after a particularly virulent epidemic from 1576-1581 the cumulative mortality at century's end was around 90 percent, and possibly as high as 95 percent in some parts of the Valle del Mezquital (Gibson 1964, 138; Melville 1990). This demographic collapse, in conjunction with the practice of

congregating dispersed native settlements into nucleated villages (*congregación*), left many terraced fields untended. Throughout the mid and late sixteenth century, Viceroy granted mercedes that turned much of these abandoned agricultural lands into rangelands (Simpson 1934, 53; Prem 1992). The mercedes contain textual snapshots of the landscape during the critical temporal interstice that existed after a tract of land was depopulated but before the Viceroy redistributed it in a merced. Although sheet erosion is not something that the region's archival documents often describe, it probably represented a greater volume of soil loss than the more dramatic landscape features that form after prolonged, unchecked sheet erosion (Stocking 1978; Livingstone 1991; Córdova and Parsons 1997). It is this class of visually impressive erosional features – which includes gullies and stony pavements – that the region's mercedes document.<sup>24</sup> This suggests that some locations experienced substantial soil erosion *before* the arrival of sheep flocks. Not all of the mercedes' reports of land degradation are associated with prior indigenous occupation, but some are. The signals of prior occupation include references to cultural landscape features, vegetative species closely associated with the indigenous cultural ecology such as maguey (*Agave* spp.) and nopal (*Opuntia* spp.), and toponyms. I have identified the following examples of each type of signal within mercedes awarded in the southeastern Valle del Mezquital.

In 1586 around Tequixquiac the Viceroy awarded an estancia on a stony hill where there was a pile of rocks that appeared to the land inspector to be a small pre-Hispanic rock pyramid.<sup>25</sup> In 1606 around Hueyoptla the Viceroy awarded an estancia on the site of a native settlement that was abandoned because of a *congregación* – the soil had been eroded to bedrock and wild maguey plants grew nearby.<sup>26</sup> Another merced in the Hueyoptla area awarded in 1589 describes a landscape that had been eroded to a stony pavement, adjacent to a stand of wild nopal plants.<sup>27</sup> Toponyms of landscape features can serve as “historical

documents” that record changes in land use (Conedera *et al.* 2007). For example, in 1568 a native received a merced for an estancia on an eroded mountain near Tequixquiac.<sup>28</sup>

Presumably because of his knowledge of the then-current Nahuatl toponyms the merced identifies this mountain by name – “Tlalcayacan” – or “place of abandoned land.”<sup>29</sup>

There emerges a tentative correlation between depopulation and degradation, but the epistemologists’ refrain echoes loudly – correlation does not prove causation. It cannot be proven that soon after those lands were depopulated sheep had not illegally grazed in them before the Viceroy redistributed them in a merced. If that were the case, then it may be that sheep herbivory and treading were the primary erosional agents after all. But it would more likely mean that herbivory and treading kept vegetative cover low, trampling weakened terrace embankments, and terrace abandonment all operated synergistically to prevent slope stabilization (Ruecker *et al.* 1998). It must also be kept in mind that some of the soil erosion may even have a pre-Hispanic provenience (Cook 1949a, 56 and 1949b, 47).

Regarding the causes of land degradation Stocking (1987, 50) cautions, “If one variable changes in association with another it is very easy to assume cause and effect, especially where the results seem to confirm one’s prejudices.” This brings our attention back to the earlier discussion on researcher positionality. But in an immediate way, Stocking’s thought implies that where grazing and environmental degradation occur together it is precarious to make an *a priori* judgement concerning livestock’s agency. The land-uses before the introduction of livestock should be explored as possible mechanisms of environmental degradation (Rowntree *et al.* 2004). This inability to isolate a single proximate cause of historical environmental transformation in the Valle del Mezquital (or anywhere else) should be neither surprising nor distressing (Figures 2.7a and b; Weiner 2005, 417). Nor

should we endeavor to construct a monocausal narrative because it would likely obscure and misrepresent the complexity of the biophysical environment (Bintliff 2002).



**Figure 2.7a.** Metepantli semi-terrace on Cerro de Aranda, looking S



**Figure 2.7b.** Degraded hillslope, exact same position as Figure 2.7a except looking N

## **Rangeland Ecology**

Rangelands have heterogeneous spatial distributions of forage and surface waters (Low *et al.* 1980). Sheep possess a spatial memory that allows them to return to their preferred resource patches (Edwards *et al.* 1996). These places that sheep visit for forage and drinking water – and the trails connecting them – experience nearly 100 percent of a flock’s trampling and nibbling (Hobbs 2006).<sup>30</sup> In semi-arid rangelands, especially those with few shade trees, sheep have high water-intake requirements (Wilson and Harrington 1984). The degradation of soils and vegetation that results from sheep congregating around watering holes is called the “piosphere effect.” At these locations sheep trails radiate outward and soil disturbance increases with proximity to the water (Andrew and Lange 1986a; Williams *et al.* 2008). Similarly, there is a pronounced decline in the abundance of forage species nearer the water (Williams and Oxley 1979; Andrew and Lange 1986b). The piosphere effect strengthens during drought conditions. This is because in a drought sheep are unable to reach food beyond their limited foraging radius, which is now anchored on the watering hole (Condon 1961; Illius 2006). At the landscape scale, the higher the number of watering points, the more thoroughly sheep can reach all potential forage areas. This means that a rangeland may support high sheep grazing densities and avoid long-term environmental impact as long as there are a sufficient number of watering points that allow adequate spatial distribution of trampling and herbivory effects (Pickard 1990).

Today, the study area has far fewer than 47 watering holes, which is the number of known estancias. It may be safe to assume that in the sixteenth century the study area did not have a watering hole within each estancia. It is unknown, especially given the prevalence of the metes-and-bounds system of land surveying, if estancieros shared watering holes or agisted their sheep around a neighbor’s surface water. The mustering of whomever’s flocks



at whichever sources of drinking water that existed at the time must have placed considerable grazing pressure on these locations. Therefore, one should be wary of ascribing to the wider landscape archival landscape descriptions of environmental degradation around watering holes (Livingstone 1991). In practice, however, it is difficult to determine whether any given location that an archival source describes as degraded reflects the biosphere effect or not. If it does, then it would be improper to impute that degradation to the wider landscape.

Sheep graze vegetation closer to the ground than do cattle and so they are better able to consume their preferred forage species (Wilson 1976). Selective grazing can lead to small annual changes in a vegetative community that over the long-term results in a considerable cumulative effect (Illius and O'Connor 1999). But neither herbivory nor drought alone is likely to drive a particular forage species to local extinction. Extinction becomes likely, however, when herbivory and drought operate synergistically (Westoby 1980; O'Connor 1991). In such situations the death of an individual plant may occur in a variety of ways. A herbivore's substantial removal of a plant's above-ground biomass may kill the plant outright, but this will likely just weaken it. The proximate cause of death will probably come from insects, fungi, or its diminished rooting ability, which makes it less competitive with other vegetative species for soil moisture (Hendrix 1998).

Vegetation mediates many of the effects that herbivory has upon soils. A reduction in the amount of foliage increases the incidence of raindrops that directly impact and compact the topsoil. Reduced foliage also increases the amount of insolation reaching the soil and thereby increasing soil temperature while reducing soil moisture. In the event of plant death there will be fewer roots to bind the soil as well as fewer stems and ground litter to slow overland water flow (Johns *et al.* 1984, 37).

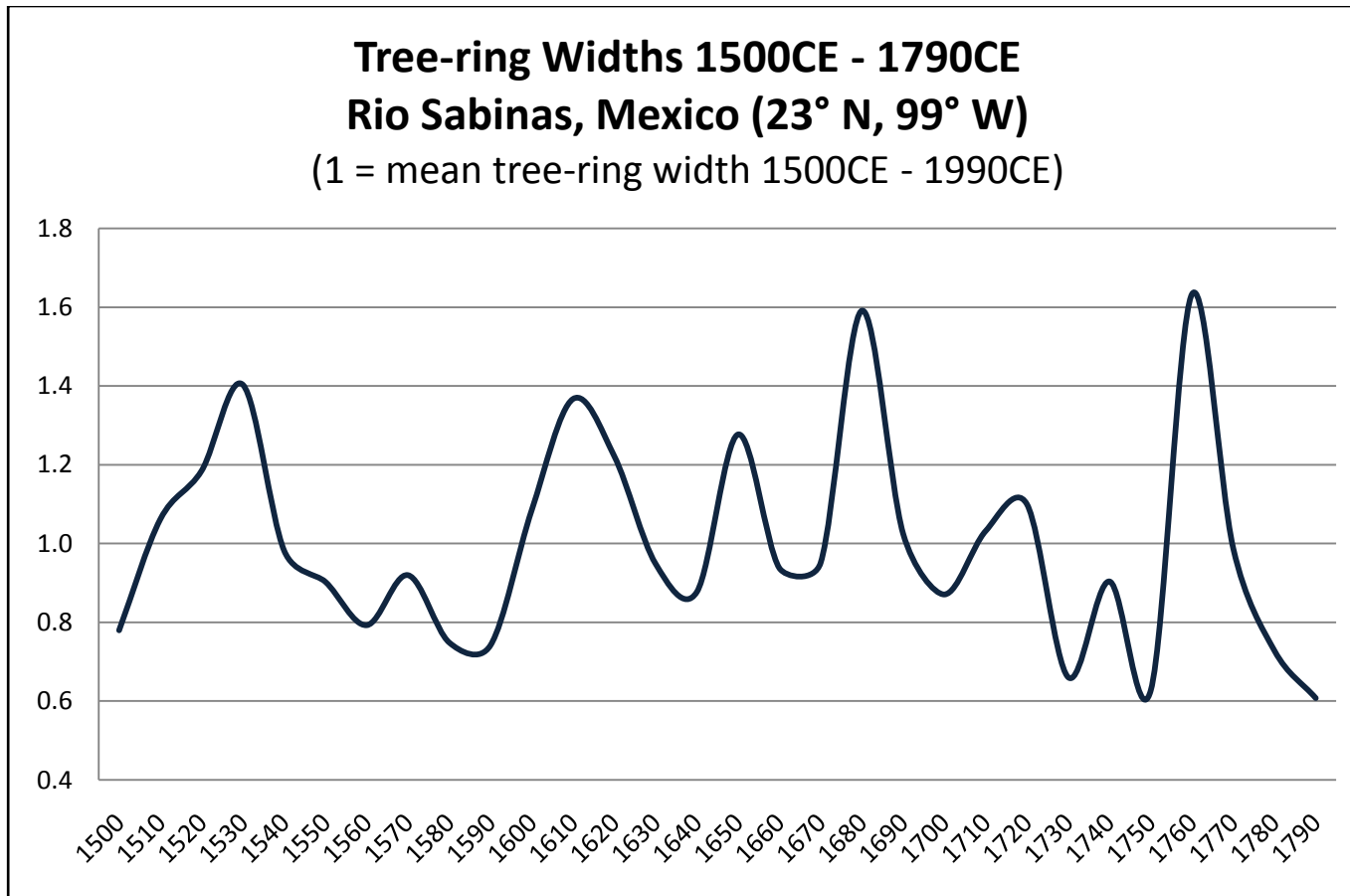
Carrying capacity is conceived of as number of head a range can support in years of average precipitation. Semi-arid rangelands with high inter-annual variations in precipitation belie the value of determining a static carrying capacity (Sullivan 1996; Turner 1998; Sayre 2008). Also, it is difficult to quantify the contribution of stubble fields and other spatio-temporal key resource areas to the range's carrying capacity (de Leeuw and Tothill 1993). A related and more straightforward concept in rangeland ecology is grazing density, which is the number of head per unit area. Melville (1994, 80-1) calculates the Valle del Mezquital's decadal sheep grazing densities. She does this by applying references to stocking rates she found in various archival documents to the region's estancias. She believes that the 1560s through 1580s witnessed the highest grazing densities and these densities explain archival evidence of environmental degradation toward the end of the century. The problem is how can meaningful grazing densities be calculated at any scale of analysis because sheep were shepherded, not immured? Moreover, a particular grazing density may not lead to unsustainable grazing pressure ("overgrazing") in years of normal (or above normal) precipitation but may do so in drought years with the same number of sheep (Freudenberger *et al.* 1999; Manzano *et al.* 2000). Even if precipitation data existed for the Early Colonial Period, the spatio-temporal stochasticity of precipitation events leads to what Noy-Meir (1973, 31) describes as "the inadequacy of averages." When a semi-arid range degrades, the blame may be mistakenly attributed primarily to a grazing density in excess of a conceived carrying capacity rather than to climatic variability (Warren 1995).<sup>31</sup> Moreover, a range's spatial extent does not experience a uniform grazing density because sheep exploit certain areas more intensively than others (Squires 1976). The lack of consideration for climatic variability and spatial heterogeneity inherent to the grazing density concept makes it a poor



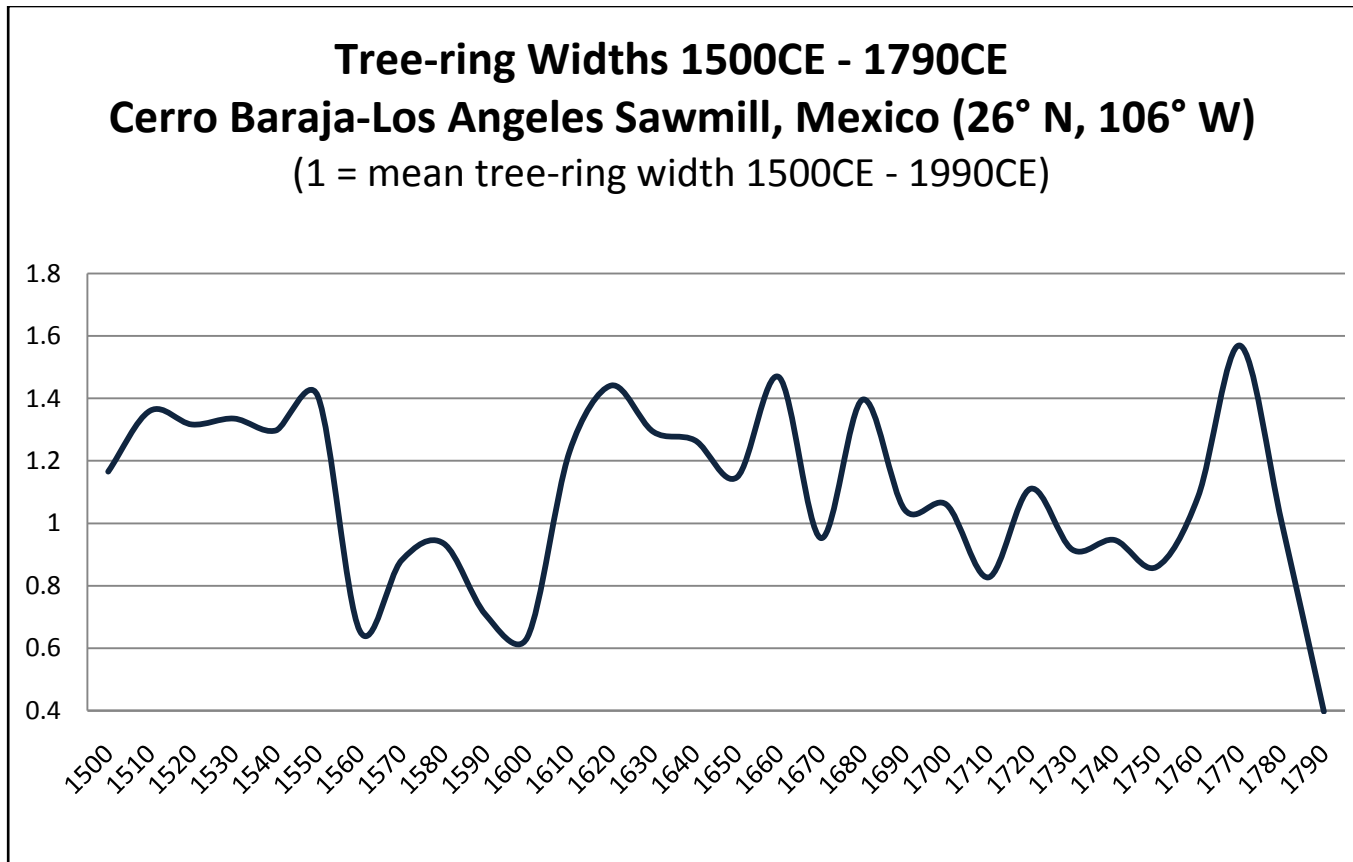
tool to explain, in the essentialist manner it does, environmental transformations (Zimmerer 1994).<sup>32</sup>

In the mid-to-late sixteenth century North America experienced a “megadrought,” which was the region’s most severe drought in the last 500 years (Stahle *et al.* 2000). It was likely the result of a strong ENSO (La Niña) effect with cold offshore currents (Cleveland *et al.* 2003). The megadrought is revealed by dendrochronological research on tree stands in the Sierra Madres as well as further south in Puebla (Figures 2.8a and b). These studies indicate that northern and central Mexico experienced severe droughts from the 1540s until about 1580, and again in the 1590s (Cleveland *et al.* 2003; Therrell *et al.* 2006; Stahle *et al.* 2007; Villanueva- Diaz *et al.* 2007). Florescano’s (1980, 81) analysis of corn and cereal prices in New Spain also suggests drought conditions in the 1590s. Alone, this multi-decadal drought would have caused a decline in vegetative production. Exacerbated by herbivory, however, foliage would have been severely reduced and left the soil vulnerable to wind as well as water erosion once the rains came. After the normal precipitation regime returns, livestock numbers would not be expected to be as high as before the onset of drought. That this process led to the permanent degradation of the range would only have become known to the estancieros subsequently. Many of them may have expected that the return of the familiar, wetter precipitation regime would restore the range to its pre-drought carrying capacity. This scenario does not directly conflict with Melville’s (1994, 157) thesis that the ultimate cause of the Valle del Mezquital’s degradation was Spanish ignorance of the range’s carrying capacity. However, her degradation narrative recounts a linear over-shoot of the range’s carrying capacity with no agency ascribed to drought.

In *A Plague of Sheep* Melville (1994) bolsters her degradation narrative with a conceptual model of an irruptive oscillation of ungulate populations. According to this



**Figure 2.8a.** Mexican dendrochronology. Tree species: *Taxodium mucronatum* (Montezuma cypress). Data collected and processed by D.W. Stahle, M.K. Cleaveland, M.D. Therrell, and G. Paull. Retrieved from [www.ncdc.noaa.gov/paleo/treering.html](http://www.ncdc.noaa.gov/paleo/treering.html) (last accessed 23 February 2009)

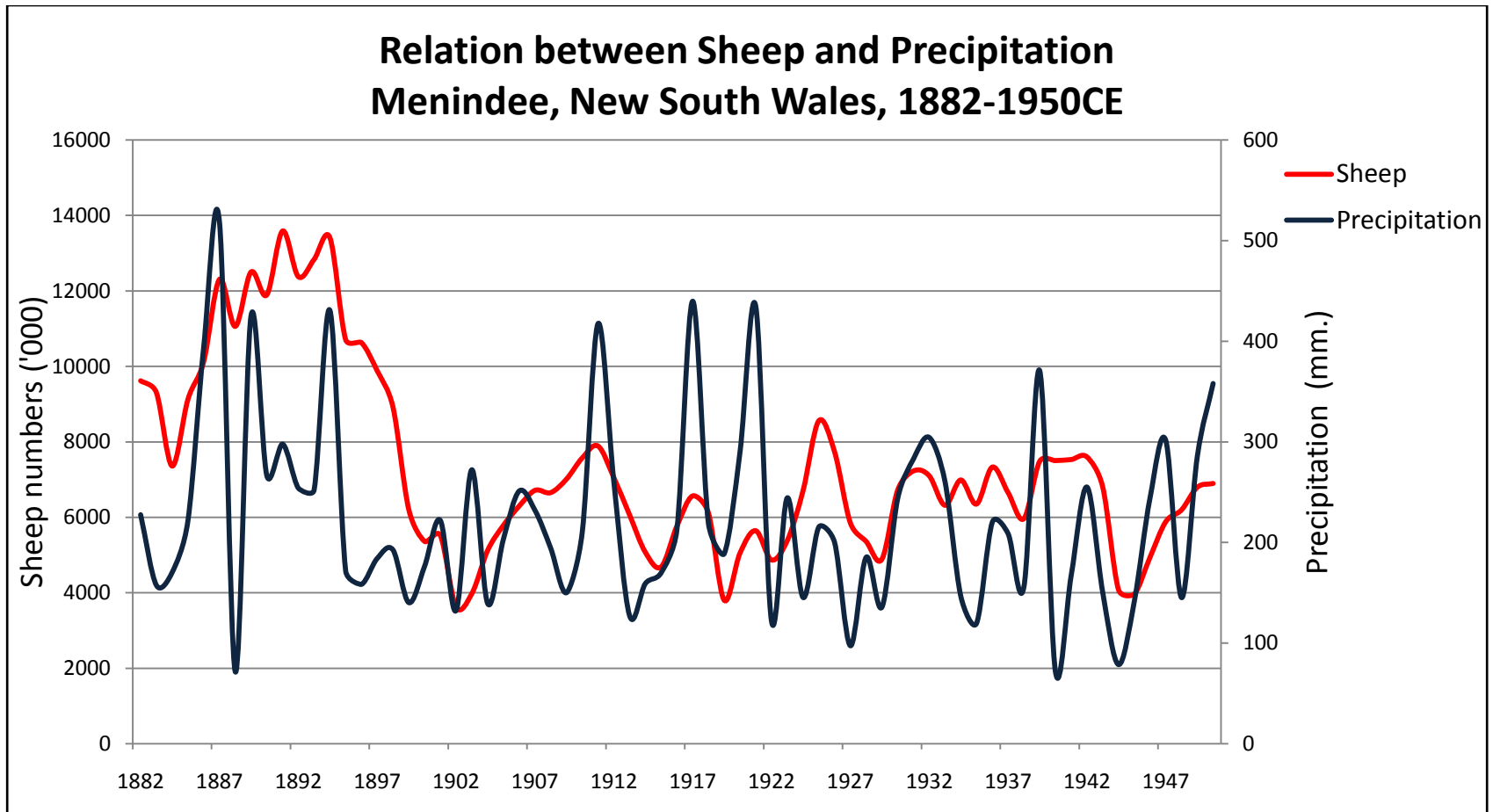


**Figure 2.8b.** Mexican dendrochronology. Tree species: *Pseudotsuga menziesii* (Douglas fir). Data collected and processed by D.W. Stahle, M.K. Cleaveland, and B.T. Burns. Retrieved from the National Climatic Data Center, [www.ncdc.noaa.gov/paleo/treering.html](http://www.ncdc.noaa.gov/paleo/treering.html) (last accessed 23 February 2009)

model, a wild ungulate population that enters a new environment will increase quickly until resources are depleted, at which time the population crashes. At the end of this process plant communities and environments are irreversibly changed and degraded. This model was innovated by Riney (1964), who developed it with data from his study of the introduction of red deer into Fjordland, New Zealand. Perhaps because pastoralists have partial to complete control over the feeding, breeding, and numbers of their livestock, I have only found one instance of this irruptive oscillation model employed to explain the population dynamics domestic ungulates. This instance is found in Caughley's (1987) analysis of the population dynamics of sheep in late-nineteenth century New South Wales, Australia, a work Melville (1994, 53) draws upon in her own use of the model. Caughley (1987, 5) acknowledges that other researchers ascribe New South Wales' sheep population crash in the late 1890s to unprecedented drought. Indeed, the occurrence of drought muddles the model's explanatory power because it becomes difficult to ascribe causality to either of them. A possible middle-ground may be offered by Leader-Williams (1988, 20), who recognizes that the population crash the model predicts may be triggered, or brought on early, by drought. Melville's intent to incorporate a biological model into her historical study is laudable. However, the lack of unambiguous examples of the model's application to domestic ungulate populations makes its explanatory power dubious in her study. Sluyter (1998, 521) did not find indications of an irruptive oscillation in his environmental study of the colonial central Veracruz lowlands. In short, I believe Melville (1994, 7) over-reaches when she declares, "These changes [resulting from the irruptive oscillation] occur whether humans are present or not." Both Riney (1964, 266) and Caughley (1976, 241) are clear that irruptions of domestic ungulates are preventable while the animals are under human management.

Melville finds sheep pastoralism in the sixteenth century Valle del Mezquital analogous to New South Wales. In *A Plague of Sheep* she devotes a chapter to this region. As in the Valle del Mezquital, she frames drought as a secondary agent of environmental degradation behind overstocking (Melville 1994, 76-7). But as in the Valle del Mezquital, drought probably had more determinacy than she describes. In fairness, Melville (1990, 36 and 1992, 152) does acknowledge that climatic drying associated with the Little Ice Age may explain some of the Valle del Mezquital's environmental change but she lacks sufficient data to explore that supposition. Into both of these regions Europeans introduced livestock unaware of the inevitable series of drought years that would befall them. For New South Wales, precipitation in the late nineteenth-century was recorded instrumentally (Lavery *et al.* 1997). These climatic data show that drought in the late 1890s was coeval with a crash in the sheep population and environmental degradation. The amount of annual precipitation influences the range's vegetative production, which in turn influences sheep numbers (Figure 2.9). In Menindee, New South Wales from 1882-1950 correlation between annual precipitation and sheep numbers is significant at the 0.05 level. When the annual sheep population is correlated with the previous year's precipitation, they are significantly correlated at the 0.01 level. The role of drought (and of course introduced rabbits) in the destruction of New South Wales' rangelands was widely known at the time (McMaster 1903, 141). In their definitive treatment of the subject, McKeon *et al.* (2004, 90) explain the degradation process for New South Wales that represents the current scholarly consensus:

The decade of the 1890s shows a large decline in average annual rainfall from 380mm. for a 5-year period (1889 to 1893), to 277mm. (1894 to 1898), with a further decline to 187mm. (1899 to 1903). The expansion of grazing in western New South Wales had only commenced in the 1870s and was supported by generally above-average rainfall from the late 1870s to early 1890s. The abrupt decline in rainfall in the late 1890s was unprecedented in terms of European experience. Not surprisingly the combination of drought and attempts to retain high stocking numbers led to the reported devastation.



**Figure 2.9.** The relation between precipitation and sheep numbers in New South Wales, Australia. Sheep population data taken from “Central Division” of New South Wales (Butlin 1962). Precipitation data retrieved from Australian Bureau of Meteorology, <http://www.bom.gov.au/climate/averages/> (last accessed February 23 2009)

As already mentioned, the natural archives preserved in tree rings reveal extreme drought conditions for central Mexico in the last two decades of the sixteenth century (Cleaveland *et al.* 2003; Therrell *et al.* 2006; Stahle *et al.* 2007; Villanueva- Diaz *et al.* 2007). If the the environmental history of New South Wales is a valid analogy, then in the early-colonial period the Valle del Mezquital had a growing sheep population that was checked by the onset of unprecedented droughts.

The intense grazing pressure throughout the drought transformed the study area into a permanently degraded condition. Grazing pressure can indeed become considerable if the range carries a high grazing density at the drought's onset. The highest mortality rate for palatable vegetative species and herbivores, as well as the most environmental degradation, will occur at the end of the drought when significant rains return (Condon 1968; Scholes 1985; Livingstone 1991; Owens-Smith 2008).<sup>33</sup> The return of the rains, especially if they arrive in intense bursts, will likely instigate massive amounts of soil erosion. This is because the drought and high grazing pressure together increase a landscape's latent instability by decreasing the above-ground biomass (Denevan 1967; Butzer and Helgren 2005). Precipitation then turns the latent instability into kinetic instability in the form of sheet erosion. An important point to make here is that "drought" and "over-stocking" do not in any immediate sense "cause" sheet erosion – the overland flow of water after a precipitation event does. Butzer and Helgren (2005, 103) describe this process succinctly: "Heavy rains trigger pulses of fluvial energy that impact the soil landscape, triggering sediment mobilization and transfer; runoff is rapid and peaks early, concentrating an excessive discharge in channels that must accommodate great volumes of water by deepening ('gullyng')." In sum, widespread soil erosion can occur in the presence of drought,

herbivory, or both because all that is required is weakend vegetation and bursts of heavy precipitation.

## **Conclusion**

Scholars who engage Mexico's colonial archival documents in an effort to reconstruct an area's livestock ecology must acknowledge and, to the degree possible overcome, three pressing methodological concerns. The first concern is the preservation rate of AGN-Mercedes. Judging by the number of mercedes I have located preserved in sources other than AGN-Mercedes, the preservation rate of AGN-Mercedes for my study area is no higher than 76.1 percent. This percentage will decrease with every merced I may find in the future preserved in sources other than AGN-Mercedes. The second concern is the variance in estancia morphology. Morphology occasionally varied with the occurrence of circular grants, although I have no evidence of these within my study area. Morphological variations were most common as a result of adjacent land-owners who had understood and accepted property boundaries based upon a series of metes-and-bounds. Livestock were not strictly immured on an estancia and so wherever they roamed or were herded represented the only meaningful estancia boundaries. The third and final concern is the estimation of estancia stocking rates. This is an important point because stocking rates impact calculations of local and regional grazing densities, and therefore also consideration of livestock's role in environmental change. The few references to stocking rates I have found for my study area are rather high. Some exaggeration may be expected considering the litigious context in which the references were provided. I propose that the best practice is to think of stocking rates in terms of a likely range between 2,000-20,000 head per estancia.

In terms of cabeceras, my study area exactly corresponds with an area that Melville studied and termed the Southern Plain. I found only 4.75 more estancias than Melville, but



she identified far more estancias whose mercedes are no longer preserved or were never issued in the first place. I believe Melville's inference of 52.7 percent of the Valle del Mezquital's estancias stems from 1) the difficulty of tracking changing estancia owners over time, and 2) an unstable local toponymy that can make it appear as though a single estancia occupies multiple locations. This dissertation's relatively small study area makes it possible to create operational maps for the first time in the study of Mexico's colonial livestock ecology. Operational maps depict how estancias more realistically occupied space, yet they are not necessarily better or worse than conceptual maps as guides to estimating the completeness of AGN-Mercedes for any given area. In chapter 5, I present a series of operational maps that help reveal the spatio-temporal pattern of land granting and the possible resultant environmental effects.

A review of the mercedes for one section of the Valle del Mezquital suggests that the region's early-colonial landscape changes may have more complex origins than can be adequately described by a monocausal narrative. Focused on sheep, Melville overlooked the probable relationship between agricultural terrace abandonment and rapid soil erosion. This relationship can be teased out of a close reading of even a small percentage of the Valle del Mezquital's mercedes once our perception of cause-and-effect widens. Because the human population decreased as the sheep population increased it is difficult in the extreme to determine how much soil erosion each process contributed to the whole. Terrace abandonment probably led to the gradual disintegration of these landesque capital features. The trampling and nibbling of sheep likely exacerbated soil erosion in many of these locations.

Dendrochronological research indicates that central Mexico experience below-normal precipitation for much of the last half of the sixteenth century. Concomitantly, sheep

pastoralism was becoming an increasingly important form of land-use in the study area as evidenced by the steady issuance of mercedes for estancias. Rather than an uncontrolled “ungulate irruption” as Melville (1994) describes, the region’s massive soil erosion may have been caused by grazing pressure that increased during the initial stages of a deep drought. At some point, the grazing pressure exceeded the available forage and sheep numbers declined. Drought-breaking rains, likely occurring at the end of multi-annual dry-wet precipitation cycles, may have caused the substantial erosion that characterizes the Valle del Mezquital’s present landscape.

### End Notes

1. My primary source for locating records held by the AGN was the Web-based searchable “Guía General” maintained by the AGN. Melville’s compilation of records for the entire Valle del Mezquital naturally included many references pertinent to my study area that I found useful. However, between her original research in 1983 the beginning of mine in 2005 the numbering scheme of AGN-Mercedes had changed. This meant that I had to correlate the old numbering system with the new for each volume in order to ensure that I had acquired all of the mercedes that she had. In the end, I believe I have accounted for each of her records. I also relied on Mario Colín’s (1967) guide to AGN-Mercedes. He includes transcriptions that have been marginally helpful. I say marginally because he regularly omits sentences, adjectives, and at times re-words the entries. Colín (1966) has a similar guide for AGN-Tierras, but this volume lacks transcriptions altogether owing to the length of these records. Gerhard (1993) includes references to various archival documents that I found useful.
2. My increasing proficiency at reading these archival documents has confirmed Villasana Haggard (1941, iv) and Baker *et al.*’s (1970, 15) assertion that one’s skill at palaeography increases with practice. Yet an accurate transcription of individual letters and words does not necessarily result in sentences that make clear sense to the contemporary researcher. To decipher an accurate meaning of unfamiliar sixteenth-century Spanish terms I referenced Cejador y Frauca (1929) and Boyd-Bowman (1971). Transcription of Nahuatl terms was facilitated by Muñoz (1952), Macazaga Ordoño and Peñfiel (1983), and Karttunen (1992).
3. The years 1559, 1562, 1580, and 1610 (AGN Guía General, <http://www.agn.gob.mx/guiageneral>)
4. AGNT v. 2704 exp. 30 f.240r.-276v.; AGNIV caja 4696 exp. 2, caja 5764 exp. 113.
5. AGNT v. 1634 exp. 4 f. 310v.

6. AGNGP v. 1 f. 181r.
7. AGNIV caja 5764 exp. 113.
8. For example, in 1930 the municipalities of Apaxco, Hueycoxco, and Tequixquiac had a cumulative surface area of 490.23 km<sup>2</sup>, in 1970 483 km<sup>2</sup>, and in 2007 423 km<sup>2</sup> (Dirección General de Estadística 1937, 18 and 1971, 3-5; Gobierno del Estado de México 2007).
9. For clarification, Melville collected her references from any and all sources available, not just from references to neighboring estancia, as Sluyter (2002, 101) describes her methodology. Regardless, inference from one source or many is fraught with the same methodological challenges.
10. AGNM v. 12 f. 209r.; AGNT 1748 exp. 1 f. 30r.-34v.
11. “Anton Bravo en nombre de Alonso de Mansilla pide un sitio de calera” (AGNT v. 2697 exp. 10 f. 309r.).
12. AGNM v. 12 f. 57r.
13. AGNT v. 2587, exp. 4, no pagination. Andres de Estrada was a local encomendero and his position may have made it easier for him to obtain a license to buy and sell mercedes (AGNIV caja 5927 exp. 6.; see Barrett 1973, 84).
14. AGNIV v. 6718 exp. 53 f. 1r. For further information on this estate see: AGNM v. 58 f. 65v.-66v.; AGNT v. 2704 exp. 30 f. 240r.-276v.
15. “en un cerro grande que nombra Maquechuacan” (AGNM v. 10 f. 198v.).
16. “en terminos del dicho pueblo en un cerro grande que nombran Tlatzalan” (AGNM v. 12 f. 56v.).
17. Elsewhere Melville (1992, 150) wrote that the in the 1580s and 1590s some estancias that the Viceroy awarded might not necessarily have represented new flocks. Rather, she suggests some estancias were acquired merely to monopolize pasture. For some reason, in *A Plague of Sheep* Melville (1994) does not mention the possible existence of these unstocked estancias, which would have helped her to justify her reduction of estancias in the final two decades of the sixteenth century.
18. In Appendix E of her doctoral dissertation Melville (1983) lists the archival documents in which she found data on land holdings. Although this appendix is usefully organized by cabecera it does not list which documents yielded mercedes and which yielded “squatters.” In *A Plague of Sheep* she retains this style of data presentation.
19. Whenever a merced is located in sources other than AGN-Mercedes it is prudent to try to evaluate its authenticity. Although there is no way to remove all doubt about

authenticity, one way to approach the matter is to determine if the merced in question dates from a year for which AGN-Mercedes has relatively complete or incomplete coverage. Of the eight estancias, seven derive from years for which AGN-Mercedes has no records (1559, 1562, 1580) and one is from a year that is only partially preserved (1568). This suggests that at least seven of these eight estancias have mercedes whose originals are for whatever reason missing from AGN-Mercedes. Additionally, two of these mercedes were awarded to the same person and derive from different ramos at the AGN, which further speaks to their authenticity.

20. AGNT v. 2704 exp. 29, f. 235v.; AGNM v. 12 f. 56v., v. 22 f. 128v.-129r., v. 23 f. 113r.
21. The compartmentalization of space reflected the European predilection to conceive of space in mathematical terms. The geometric division of space, in maps if not on the ground, facilitated the efficient colonization of new areas (Smith 1999, 50-1). A map accompanied every merced, which perhaps supports Harley's (2001, 57) contention that, "Maps were used to legitimize the reality of conquest and empire."
22. Of the 233 estancias Sluyter mapped, he inferred four as neighboring estancias and found 25 in sources other than AGN-Mercedes (29 of 233, or 12.4 percent).
23. In some cases the sequence of abandonment and erosion had occurred within the lifetimes of West's local informants. This minimizes the potential logical fallacy *post hoc ergo propter hoc*, or "after this, therefore because of it."
24. For example: AGNT v. 2812 exp. 12 f. 373r.-400v.; AGNM v. 9 f. 273r.-v., v. 12 f. 209r.-v., v. 14 f. 232v.-233r., v. 17 f. 52r.-v., v. 27 f. 271v.-273r.
25. The estancia was to be awarded on a "loma alta pedregosa a la mano derecha de un monton de piedra que parece cue antiguo" (AGNM v. 12 f. 209r.-v.). This land inspector's suggestion of a rock pyramid was probably correct. I have field-verified a pre-Hispanic rock pyramid on the low hills southeast of Tequixquiac.
26. This location for an estancia was described as a "sitio antiguo" near which "son tierras muy ruinas y lomas de tepetate" and "no hay sino algunos magueyes silvestres" (AGNT v. 2812 exp. 12 f. 373v.-400v.). Butzer and Butzer's (1997) reading of sixteenth-century land descriptions for the nearby Bajío supports a close association between maguey and an indigenous presence.
27. The estancia was to be established "junto a un pedregalejo hazia un llano donde hay unos tunales silvestres" (AGNM v. 14 f. 232v.-233v.).
28. The estancia was to be established "en un cerro pedregoso que se llama Tlalahuyacan" (AGNM v. 9 f. 273r.-v.).
29. The toponym Tlalahuyacan breaks into its Nahuatl components as follows: *Tlalli* = land, *cahua* = to abandon, *can* = place (after Karttunen 1992).

30. Sheep tend to make their nocturnal camps on hilltops and ridges (Taylor *et al.* 1984). These may be the few locations that sheep daily visit not seeking forage or water.
31. In the African Sahel through the 1970s the dominant degradation narrative also focused on overstocking as the cause of the region's desertification (Swift 1996). Overstocking was also blamed for the Sahelian drought of 1972-1974 because it was thought to reduce vegetation, which increases albedo and so reduces convection, and ultimately decreases precipitation (McCann 1999, 55-60). This narrative drew strength from a Malthusian essentialism that Bassett and Crummey (2003, 8-9) observe ". . . brings with it cause and effect ready-made. Where there is population growth there must be environmental degradation; where environmental degradation is perceived it must be explained by population growth." McCann (1999, 55-60) points out that popular television programming during the 1970s reinforced the perceived connections between desertification in the Sahel and human population growth, overstocking, and over-cultivation. Melville's narrative for the Valle del Mezquital is remarkably similar to the scientific understanding of the Sahel in the 1970s and it is interesting to consider how this may have influenced her understanding of rangeland ecology. The emerging counter-narrative in the Sahel relies upon local histories and empirical evidence to show that the desert expands and contracts with stochastic precipitation receipts, and these receipts are more strongly coupled with oceanic temperatures than vegetative cover (Tucker *et al.* 1991; Mattsson and Rapp 1991; Little 1994, 215; McCann 1999, 55-60).
32. These critiques of carrying capacity and grazing densities are closely related to the "new ecology." Botkin (1990, 62) eloquently describes this perspective: "Wherever we seek to find constancy we discover change . . . we find that nature undisturbed is not constant in form, structure, or proportion, but changes at every scale of time and place. The old idea of a static landscape, like a single musical chord sounded forever, must be abandoned, for such a landscape never existed except in our imagination."
33. If the drought-breaking rains are cold, then the weakened sheep with their thick wet hair may shiver to death (McCabe 1987).

## CHAPTER 3: THE NATURAL ENVIRONMENT

### Introduction

This chapter outlines the study area's physical environment prior to human occupation. Because this chapter excludes human culture, it is possible to bypass many confounding variables, such as the extent of anthropogenic modification of the pre-Hispanic physical environment (Denevan 1992), the "ecological transition" (Bennett 1976), livestock as geomorphic agents (Trimble and Mendel 1995), and the practical and philosophical degree of separateness (if any) between culture and Nature (Freud 1928; 26; Coates 1998; Ingold 2000). With these issues temporarily placed to one side, a safe harbor emerges that allows one to unambiguously refer to the physical environment in its more colloquial guise, the *natural environment* (Worster 1988, 292).<sup>1,2</sup>

The preceding is not merely (or only) an indulgence in nomenclatorial aesthetics, but also a matter of utmost practicality with direct bearing upon the main intellectual thrusts of this dissertation. The basic elements of the natural environment must be recognized and understood so that the pre-Hispanic and early-colonial (non)anthropogenic impacts upon the biotic and abiotic environmental substrates can be identified and evaluated as to their degree and, if possible, causation. More dynamically and less encyclopedically, how these elements have changed over geologic timescales should also be reviewed in order to glean important insights concerning the degree and causes of environmental transformations during the historical period. This framing of the natural environment as always in a state of transition eschews the notion that Nature ever reaches a "climax" state (Cronon 1983, 9-10).<sup>3</sup>

The natural environment as defined above is but the first of the three major environmental phases that the study area has passed through that are germane to this

dissertation. I discuss the second phase in the subsequent chapter, The pre-Hispanic Inhabited Environment. This is the natural environment as occupied by pre-Hispanic culture groups. The third phase represents this dissertation's main focus – the environment of the Early Colonial Period. This is the second phase as altered by the introduction of European biota, the demographic collapse of the indigenous population, the socio-political reorganization of space, and so forth. The transition from the first phase to the second was exceptionally gradual relative to the transition from the second to the third, occurring over millennia rather than decades. The processes of environmental change that operated during the second and third phases cannot be fully understood without a close study of the processes of change that operated during the first. This is because the classification of environmental phases is only meaningful as regards the *agency* of environmental changes. Generally, all of the elements of the first phase persisted into the subsequent two phases. Although a phenomenon such as the topography has remained largely unchanged, others such as climate have fluctuated, soils have become redistributed, and certain vegetative species have increased or decreased in dominance. This is all rather intuitive, but lamentably both historical geographers and environmental historians have at times neglected a serious study of the first environmental phase (Trimble 1992, xvi-xvii).

Discussion of the natural environment also answers Meinig's (1982, 71) exhortation for scholars to skirt ideological barriers by “. . . seek[ing] first of all to understand as clearly and dispassionately as possible *what has happened*. . .” (emphasis in original).<sup>4</sup> Furthermore, a review of the natural environment is necessary to help prevent misconceptions or misinterpretations about environmental changes during the pre-Hispanic and early-colonial periods, or what in regards to more general geographical research Lewis (1998, 512) describes as “Premature aesthetic or ideological judgments.” Martínez-Fernández and

Esteve (2005) also espouse a better understanding of the natural environment of semi-arid zones in particular by pointing out that not all of them have been anthropogenically degraded, and nor should they be (dis)regarded as such.<sup>5</sup>

This chapter proceeds in three sections: geomorphology; climate and hydrology; and vegetation. I discuss these topics with broad strokes for two reasons. First, because humans have inhabited the study area for millennia it is difficult to positively determine what may be anthropogenic. Second, this chapter's purpose is merely to outline the most basic elements of the physical environment in order to understand how these elements operate without a human presence.

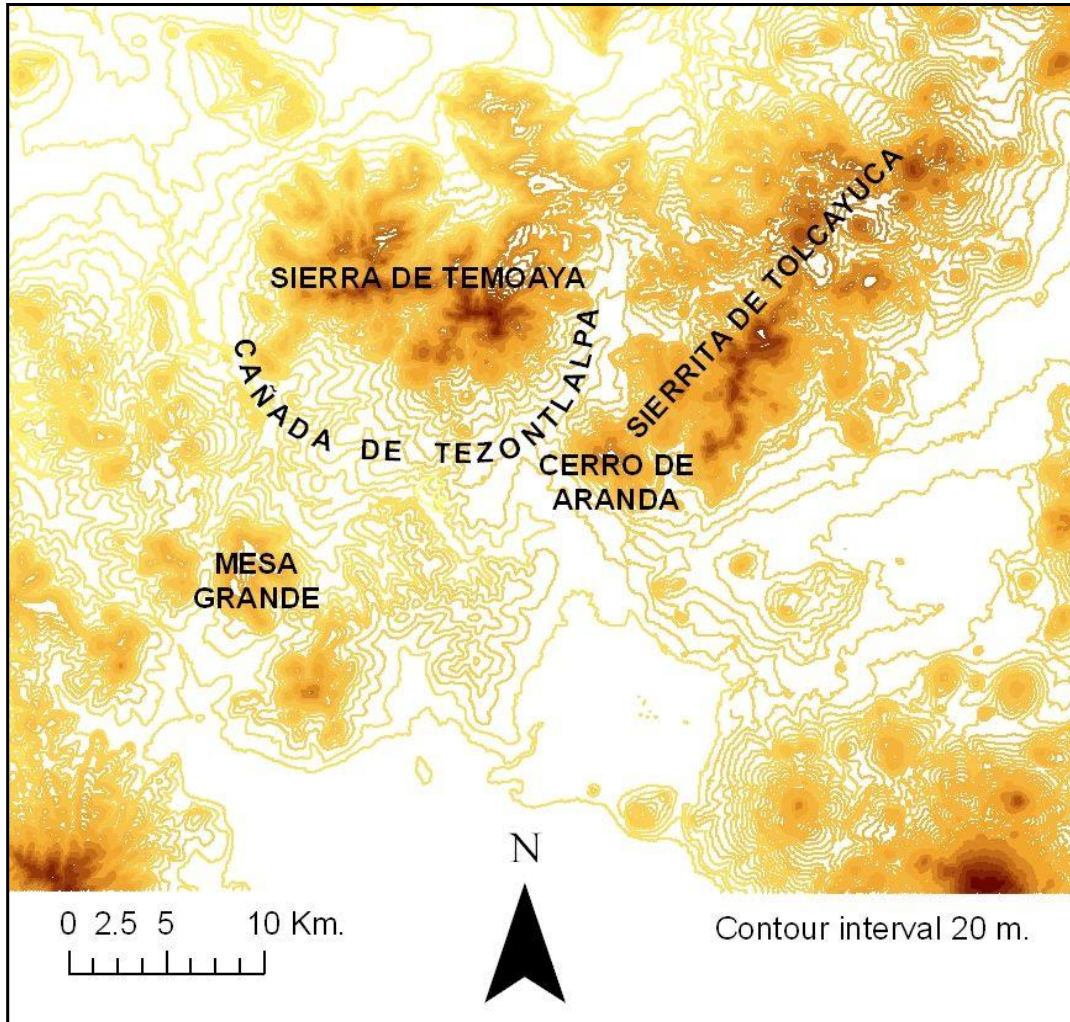
### **Geomorphology**

The development of the Trans-Mexican Volcanic Belt (TMVB) is responsible for the study area's most prominent geomorphological features. The TVMB is a continental magmatic arc that arose during the middle Miocene in response to the Rivera and Cocos tectonic plates subducting in a northeasterly direction underneath the North American plate. The subduction has created around 8,000 volcanic structures along a swath that ranges between 80 and 230 km in width and extends about 1,000 km in length from the Pacific coast to the Gulf of Mexico (Gómez-Tuena *et al.* 2007, 130).

The study area presents a mix of elevational zones (Figure 3.1). In the north, the Ramal del Cerro Alto de Temoaya (hereafter Sierra de Temoaya) is a prominent east-west running chain of mountain peaks. Elevations within the sierra gradually increase eastward from 2,680 m to 3,000 m. In the study area's east-central portion, Cerro de Aranda reaches 2,700 m in elevation. Running northeast from the Cerro de Aranda the Sierrita de Tolcayuca gradually increases in elevation from 2,740 m to 2,860 m. The final significant elevation is



the mesa immediately west of Tequixquiac, Mesa Grande (or Mesa Ahumada), with a peak elevation of 2,560 m (N.A. 1937).<sup>6</sup>



**Figure 3.1.** Topography and elevational features

Recent geochemical testing reveals that the major elevational features are of different ages and chemical compositions. The Sierra de Temoaya and Sierrita de Tolcayuca are Miocene (~19-10 mya) andesitic arcs (Gómez-Tuena *et al.* 2007, 132-3), interdigitated with breccia and ash (Instituto de Geología 1962), and possessing rhyolitic and basaltic peaks (Instituto Geológico de México 1937b). Cerro de Aranda and Mesa Grande are late Pliocene-Quaternary (<3 mya) mafic volcanic structures (Gómez-Tuena *et al.* 2007, 132-3) with basaltic

peaks (Instituto Geológico de México 1937b). The U-shaped lowland located roughly in the study area's center is called the Cañada de Tezontlalpa (N.A. 1937). This physiographic region extends southward from Apaxco toward Tequixquiac, eastward to Hueyopxtla, and northward along the western edge of the pueblo of Tezontlalpa (INEGI 1:50,000 topographic map E14A19, 1997). This lowland area is generally composed of clastic material with lenses of lacustrine limestone and volcanic ash, interdigitated locally with mafic lava deposits (Instituto de Geología 1962).

The study area's higher elevations are calcaric Regosols. These are poorly developed soils comprised of unconsolidated materials that lack a mollic horizon (FAO 2006, 92).<sup>7</sup> The soil formerly overlaying many of the denuded mountains of the Sierra de Temoaya must now comprise the surface layer of much the lower-elevation haplic Phaeozem soils (Figure 3.2; Secretaría de Programación y Presupuesto 1981; Martínez-Fernández and Esteve 2005, 531; Prado *et al.* 2007, 311). Phaeozem soils are also unconsolidated but unlike the Regosols they have a mollic A horizon, and high porosity and fertility (FAO 2006, 88). Much of the study area is underlain by a carbonate horizon, and the so soils can be classified as Pedocals (Marbut 1928, 20). This pedogenic carbonate horizon formed through calcification (Hunt 1972, 169). Calcification occurs when calcium bicarbonate ( $\text{Ca}[\text{HCO}_3]_2$ ) in solution illuviates through the soil profile after a precipitation event. Upon drying, calcium carbonate (calcite,  $\text{CaCO}_3$ ) is precipitated as secondary carbonates at the deepest level to which the calcium bicarbonate had penetrated (Gile and Grossman 1979, 141-2; Goudie 1983, 114; FAO 2006, 47). The noncalcareous zone is therefore relatively shallow in this region of low average annual precipitation (500-700 mm) because the calcium bicarbonate does not have sufficient moisture to illuviate more than a meter (Jenny 1941, 123). The precipitate is a whitish (owing to the calcite), indurated layer of calcium carbonate, which is a type of limey duricrust



**Figure 3.2.** Confluence of two incised streambeds. Background, denuded slopes of a cerro in the Sierra de Temoaya. East of Santa María Ajoloapan, looking N

known as calcrete (Goudie 1973, 5) or the petrocalcic layer (FAO 2006, 29). In central Mexico this layer of pedogenic carbonate is called *caliche* or *tepetate* (hereafter caliche) and exists as a subsurface horizon within much the Valle del Mezquital.<sup>8,9</sup> In the flatter areas, caliche is on average just 28 in below the surface whereas on steeper slopes it is nearer the surface or even exposed. Seldom does it exceed 1 m in thickness (Figure 3.3; Ortiz Mena 1938, 175, 237). In locations with bare, thin soil water will infiltrate downward until it reaches the caliche layer and then spread laterally to wash away the soil through sheet erosion (Cook 1949b, 15). When gullies experience seasonal flow calcification proceeds as the calcium bicarbonate in run-off waters from higher elevations seeps into gully walls.<sup>10</sup> This “case hardening” can occur within channel walls for up to 3 m in lateral depth and also upon the



channel bed to form lamellar caliche (Figure 3.4; Lattman and Simonberg 1971, 276, 279-80). Channel-bed calcification reduces infiltration and this lowers groundwater recharge rates (Cooley *et al.* 1973, 17).



**Figure 3.3.** Phaeozem soil overlying caliche at road cut, 1 km E of Tezontlalpa



**Figure 3.4.** Unconsolidated alluvial material overlying lamellar caliche at site of abandoned village Tezcatepec. The hammer's head rests at a stratigraphic unconformity

### **Climate and Hydrology**

Because of its tropical situation, the inter-tropical convergence zone (ITCZ) has much influence over central Mexico's climate. The ITCZ is far to the south during the Northern Hemisphere winter and the sub-tropical high pressure belt allows stable, dry air to dominate. Although this is the dry season, depressions can still bring precipitation into the region (Metcalf 1987, 211-2). During the Northern Hemisphere summer the ITCZ occupies a more northerly position, which allows the Westerlies to engage in a highly zonal flow pattern. The easterly Trade Winds can then transport moist tropical air from the Caribbean basin towards central Mexico. Summer convective activity, often in the form of easterly waves, produces



most of central Mexico's annual precipitation (Wallén 1955, 55; Metcalfe 1987, 211-2). The *canícula*, or mid-summer drought, lasts around two weeks during August. One theory for this period of dryness is that it is caused by fluctuations in sea-surface temperatures off the Pacific coast (Magaña *et al.* 2003, 317).

Annual deviations from long-term averages of summer temperature and precipitation occur when strong meridional flows block the moist Trade Winds and cause below-average precipitation as well as early or late frosts (Jáuregui 1995, 43; O'Hara and Metcalfe 1997, 26).<sup>11</sup> The El Niño Southern Oscillation (hereafter El Niño) can also cause deviations. During an El Niño year the ITCZ does not migrate to its usual northerly position in the summer and Hadley cell convection produces strong subsidence over central Mexico. This depresses convective activity and leads to summer drought conditions as well as unusually cold winters (Magaña *et al.* 1999, 29 and 2003, 321). Winter climatic deviations can occur when strong meridional flow brings southward cold polar air (*nortes*) that results in abnormally low temperatures and frosts (Metcalfe 1987, 211-2; Jáuregui, 1997, 16).

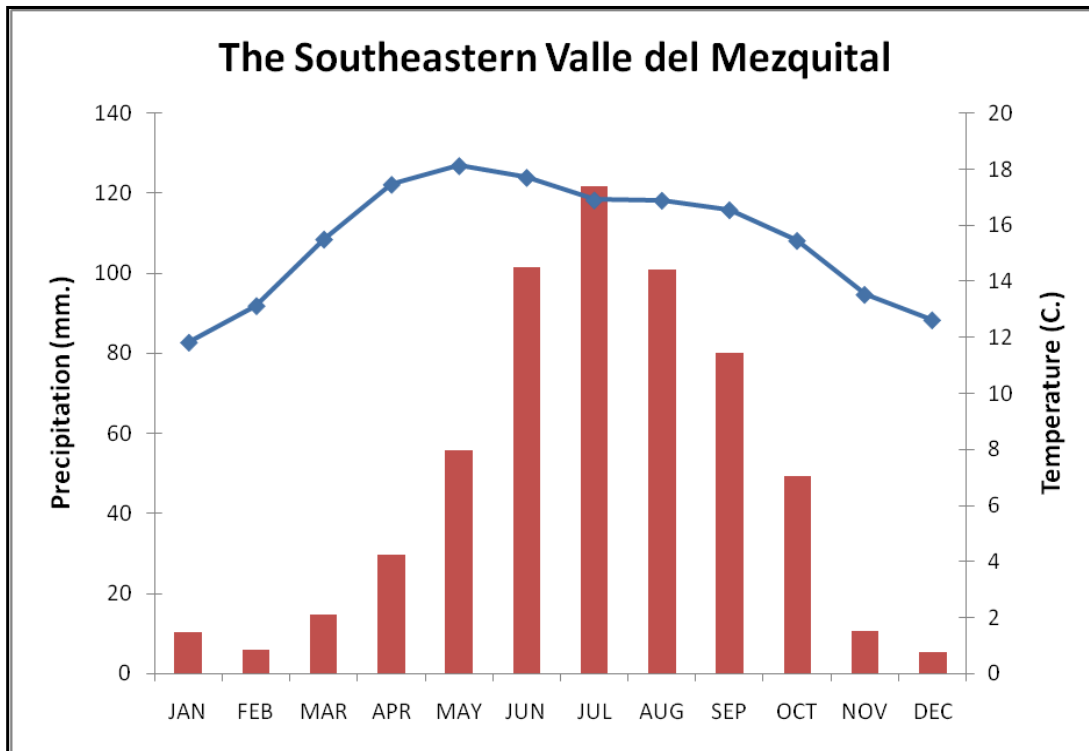
Because of low chronological resolution and poor spatial coverage, a clear understanding of Mexico's palaeoclimatological record has yet to emerge. However, preliminary lines of evidence generated by indirect observational methods, such as palaeolimnological and palynological data, indicate that the Holocene (10,000BP-present) has been relatively climatically stable. The exception is that the Middle Holocene (7,800-3,200BP) appears to have experienced more zonal atmospheric circulation that made it slightly warmer and wetter than the epochal average (Voorhies and Metcalfe 2007, 180). Mexico's medium-term climatic events for the historical period are becoming better understood. One of these was the Medieval Warm Period (~900-1200CE) (Fagan 2008). In this period Mexico was drier than normal but afterwards returned to normal or above-

normal wetness (Metcalf 1987, 215; Acuña-Soto *et al.* 2005). The Little Ice Age (~1500-1850CE) is another period of climatic deviation, one marked by cooling (Grove 2004). A small decrease in solar irradiance appears to have led to the Little Ice Age (Polissar *et al.* 2006, 8938) and volcanic eruptions exacerbated the solar forcing at the decadal scale (Crowley 2000, 271). In Mexico, this period was marked by atmospheric cooling and drying (Endfield and O'Hara 1997, 268; Hodell *et al.* 2005). By the end of the nineteenth century the Industrial Revolution and its associated atmospheric warming appears to have brought the Little Ice Age to a close (Ruddiman 2005, 121).

Mexico's meteorological data collected instrumentally over the last century are neither temporally deep nor spatially broad. Only fifteen weather stations have meteorological observations dating back to the 1930s (Jáuregui 1997, 7). Over recent decades, six weather stations within or near the study area have taken meteorological observations. These data can provide insights into the study area's climatic regime (Table 3.1). Occasionally, a single or multiple months' data were not recorded in a particular a year. The more frequently monthly data are missing, the fewer the consecutive years of complete observational data. Consecutive data are important for establishing precipitation trends.

**Table 3.1.** Precipitation data collected by the six weather stations in or near the study area

<b>Weather station</b>	<b>Years of complete observational data</b>	<b>Consecutive years</b>	<b>Average annual precipitation (mm)</b>
<b>Tula</b>	1961-1967, 1970-1988	19	568.1
<b>Huehuetoca</b>	1961-1963, 1965-1977, 1980-1988, 1997-2000, 2006	13	625.2
<b>El Tajo (Tequixquiac)</b>	1962-1963, 1965-1978, 1980-1988, 2001, 2003	14	701.88
<b>La Mora (Apaxco)</b>	1973-1986	11	612.5
<b>Jilotzingo</b>	1961-1966, 1968-1987	20	593.5
<b>Nopala</b>	1981-1989, 1991-1992, 2002-2005	9	479.2



**Figure 3.5.** Climograph (see Table 3.1 for metadata)

The study area is within semi-arid Mexico (Meigs 1953, 204). Average daily temperatures range between 13°C in winter to 17°C in summer with an annual average temperature of 15.5°C. The warmest month, May, immediately precedes the wettest months of June through August. On average, the area receives between 500 and 700 mm of annual precipitation with 85 percent arriving in pulses between April and September through convective storms (Figures 3.5 and 3.6; Comisión Nacional del Agua 2007). The region experiences water budget deficits during the dry-season and has an annual deficit of around 130 mm (Thornthwaite 1964, 400-1).<sup>12</sup> However, because the study area is located in a tropical semi-arid region that is susceptible to the influences of El Niño, the inter-annual variation in annual precipitation can be high (Nicholls and Wong 1990). The degree of stochasticity between years can be determined by calculating the percentage of the coefficient of variation (standard deviation of precipitation / mean, hereafter CV). The

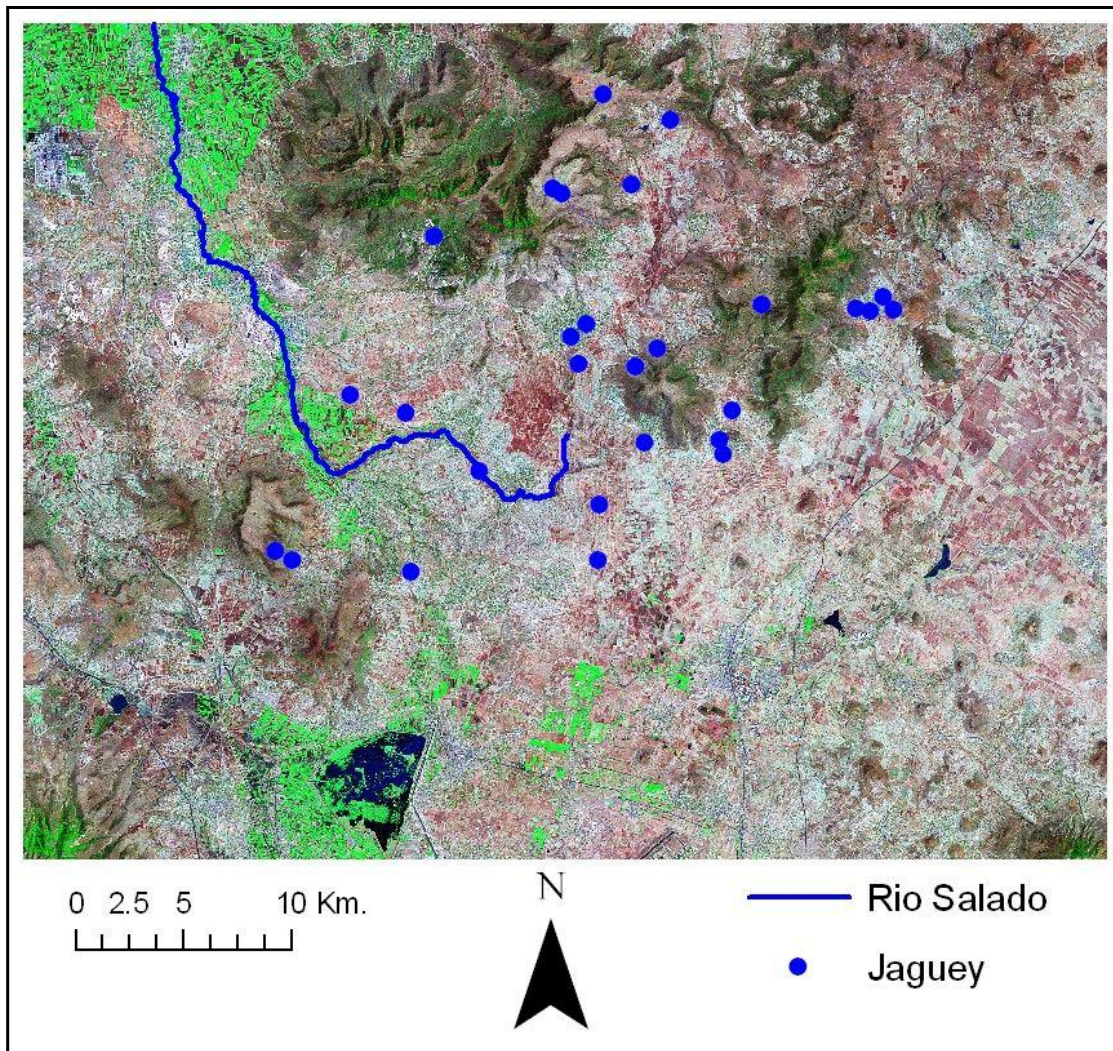


weather station with the most consecutive years of complete precipitation data is Jilotzingo, with a 20-year record. The CV for this weather station is 20.69 percent. The other five stations within or near the study area have CVs that range between 15.01 percent and 20.89 percent (Comisión Nacional del Agua 2007). Although somewhat lower, these values correspond well with the CV of 26.90 percent that Wallén (1955, 68) calculates for Pachuca, roughly 30 km to the northeast.



**Figure 3.6.** Convective summer precipitation. SE of Hueypoxtla, looking N. August 2006

The study area is bounded to the south by the Basin of Mexico. It is drained by the north-flowing Salado de Hueypoxtla, a tributary of the Tula River within the Pánuco River drainage system (Figure 3.7). Even though the Salado de Hueypoxtla is the study area's largest stream, today it is ephemeral and flows only during the rainy season. Its headwaters



**Figure 3.7.** Hydrological features (base layer: Landsat 5 satellite image)

are the springs just north of Tlapanaloya that coalesce into a coherent channel roughly 1 km northeast of Hueypoxtla (González and Delgadillo 1973, 18; Ramos Duarte 1999, 20). It then flows a short distance southwest to skirt Hueypoxtla’s southern reaches and turns northeast to pass through Tlapanaloya. It continues westward to pass the northern side of Tequixquiac, at which point it changes name to Rio Salado. Once past Tequixquiac the stream turns sharply northward and flows through Apaxco (INEGI 1:50,000 topographic map E14A19, 1997). Other important streams are the arroyos that flow in southerly directions into the Rio Salado, draining the Sierra de Temoaya. Depressions that contain water for



either all or only part of the year are called *jagüeyes* (Figure. 3.8). They are plentiful in the study area, but it is difficult to determine their ages and which are naturally occurring.



**Figure 3.8.** Jagüey immediately south of San Miguel Tepetates, looking NNW. August 2006

### **Vegetation**

Adumbration of the study area's vegetation necessarily follows the discussions of geomorphology and climate owing to the considerable influence of those two factors upon the composition of the vegetative community. Slope, aspect, and other microenvironmental conditions influence a location's soil catena and so also the structure of its vegetative community. Steeper slopes have thin, nutrient-poor soils that can only support sparse vegetative cover. In the more level areas of higher elevations are woodlands mixed with oak (*Quercus* spp.) and pine (*Pinus* spp.), with the former often forming the understory.

*Juniperus* spp. (generally *J. flaccida* in México and Hidalgo states) is a common transition species between an oak-pine woodland and matorral (Rzedowski 1978, 293, 311-2). Shallower slopes on foothills and the flatlands have more highly developed, nutrient-rich soils that can support denser herbaceous and grass species. Because of extensive anthropogenic disturbance in central Mexico it is difficult to discern which grass species dominated before the arrival of humans. Today, common species are *Hilaria cenchroides*, *Abildgaardia mexicana*, *Bouteloua radicata*, and *B. hirsuta*. *B. hirsuta* appears to be particularly dominant on rocky hillsides with thin soil cover (Rzedowski 1978, 220-2). Willows (*Salix* spp.) grow in the humid lowlands, often near watercourses. South-facing slopes receive more solar radiation annually and this creates drier soils that are more favorable to xerophytic plant communities (Mutanga *et al.* 2004).

The widespread occurrence of caliche within a few feet of the soil surface necessarily implicates it in the dynamics of the vegetative community. An important component of the caliche-vegetation relationship is that caliche is impenetrable to roots. When roots encounter caliche they must begin to grow laterally (Nimlos and Ortiz-Solorio 1987, 83). This favors some xerophytic shrubs such as mesquite (*Prosopis juliflora*) because although their roots cannot penetrate the caliche they will grow laterally until they locate a crack. Once a crack has been found the shrub's roots can grow windingly downward for up to 5 m to reach deeply buried soil nutrients and moisture. During a drought the shrubs' rooting abilities give them a decided advantage over annual grasses, whose roots will not penetrate more than 1.6 m through caliche's cracks (Gibbens and Lenz 2001). Deep or prolonged droughts permit xerophytic shrubs to encroach into areas where there were previously unable to compete with annual grasses (Hastings and Turner 1965; Scifres *et al.* 1971; Haas *et al.* 1973; Gibbens *et al.* 2005). Conversely, in periods of above-normal precipitation a thin layer of soil over

caliche can become waterlogged, which can induce plant mortality through over-saturation (Ortiz Mena 1938, 176).

Precipitation is the single greatest variable that influences the vegetative community at the landscape scale (Seely 1978; Hoffman *et al.* 1990). Normal or above-normal summer precipitation increases vegetative production, which in turn increases vegetative basal cover. This cover intercepts the impact of raindrops before they reach the soil surface and preserves soil porosity. Highly porous soil allows precipitation to infiltrate through the soil profile and into the rooting zone rather than flow over the surface in an erosive sheet (Elwell and Stocking 1976; Shaxson and Barber 2003, 20). Within a well-developed and watered rooting zone a certain number of roots regularly die and decay, leaving empty channels that help to perpetuate porous soil conditions (Webb *et al.* 1988, 6). Because a drought event limits vegetative production and decreases basal cover, heavy drought-breaking rains can decrease soil porosity and increase sheet erosion. Sheet erosion will be most extensive between locations where the basal cover did not decrease, such as underneath a shrub canopy. This amplifies edaphic heterogeneity at the landscape scale to the benefit of an increasingly dominant shrub community (Wright and Van Dyne 1981, 20; Schlesinger *et al.* 1990, 1044).

Precipitation is also important to vegetation because it transports plant nutrients into the rooting zone (Shaxson and Barber 2003, 23). In the highlands of semi-arid central Mexico, plant nutrients come primarily from the deposition, decomposition, and mineralization of leaves. Legumes that are in symbiosis with N<sub>2</sub>-fixing bacteria, such as mesquite and huizache (*Acacia farnesiana*), have soils under their canopies that are much higher in nitrogen and carbon content than locations between these species. On average, the soil beneath mesquite and huizache is two to three times richer in carbon and three

times richer in nitrogen than ambient levels. Because huizache sheds its leaves twice a year and mesquite only once, the soil beneath the former's canopy is particularly nutrient-rich (Reyes-Reyes *et al.* 2002; Herrera-Arreola *et al.* 2007). Large perennial species, such as nopal (*Opuntia* spp., or prickly pear) and yucca (*Yucca* spp.), often grow alongside mesquite, huizache and other woody species in stands called *nopaleras* (Janzen 1986, 595). Nopaleras are one of semi-arid central Mexico's most diverse plant communities (González-Espinosa 1999, 350). The development of a nopalera at a site may begin with the establishment of legumes. The leguminous species create a nutrient-rich microhabitat for non-leguminous species to also inhabit (Yeaton and Romero Manzanares 1986, 215; Granados Sánchez and Castañeda Pérez 1991, 29).

Many of the shrubby perennial species in a nopalera bear large, fleshy, sometimes-sweet fruits that are occasionally consumed by wild and domesticated mammals. The attractiveness of the fruit to today's mammals likely indicates the fruit's co-evolution with North and South America's now-extinct megafaunal species (Mooney *et al.* 1977, 39). Until their extinction in the Late Pleistocene, *Glyptodonts*, *Proboscideans*, and other megafaunal species browsed those fruits and benefitted the vegetative species by acting as their primary vectors of endozoochorous seed dispersal (Janzen 1986, 599). Ground sloth (*Nothrotheriops shastensis*) and mammoth (*Mammuthus* spp.) dung that has been radio-carbon dated to the Late Pleistocene contains *Opuntia* and *Prosopis* seeds (Long *et al.* 1974, 1845; Davis *et al.* 1984, 274). After the megafaunal extinctions, various small mammals – including deer mice, jackrabbits, ground squirrels, and others – were the remaining vectors of seed dispersal (Janzen 1986, 603-4). That is, until the “Columbian Exchange” and the introduction of several species of bovids into North America (Crosby 1972).

## **Conclusion**

The study area lies within the Trans-Mexican Volcanic Belt and its topography is the result of different periods of volcanism throughout relatively recent geologic time. Underlying much of the study area is a soil horizon of indurated calcium carbonate that functions as a sort of pedogenic bedrock. This horizon, locally known as caliche or tepetate, is present in much of semi-arid central Mexico. The precipitation regime is highly bimodal with distinct wet summer and dry winter seasons. As the ITCZ moves northward in the summer, precipitation arrives in the form of easterly waves from the Caribbean basin. Significant variations from climatic averages have occurred in recent centuries and reflect global-scale processes (the Medieval Warm Period and Little Ice Age). Annual variations in precipitation are regularly 15-20 percent, representing a moderate but not unusual amount of stochasticity for a semi-arid region. The study area's main watercourse is the Rio Salado and various water holes dot the landscape. Aspect, slope, elevation and soil conditions influence the composition of the vegetative community at any particular location. The pre-Hispanic distribution and dominance of certain vegetative species is unknown. To conclude, global-scale processes, such as atmospheric circulation, and local factors, such as the aspect of a hillside, have all operated synergistically over multiple timescales to provide the contours of the study area's natural environment.

## **End Notes**

1. Yet it is impossible to completely escape the social construction of Nature because the author must necessarily rely on his or her own culturo-academic background to frame the analysis (Blaikie 1995, 212).
2. The term "landscape" is here avoided because it denotes a dynamic relationship between culture and nature (Baker 2003, 78). Even when preceded by modifiers, as in "natural landscape" and "cultural landscape," these are frequently paired terms that are not generally understood to have meaning in the absence of the other. Therefore, "environment" is the preferred base term.

3. Some recent thought experiments have underscored the substantial changes in the physical environment that would occur over the short and long terms were humanity to suddenly blink out of existence (Holmes 2006; Weisman 2007).
4. I broadly interpret Meinig's focus on a straightforward accounting of the past to include geologic time.
5. Zachar (1982, 129) recognizes two types of unproductive land distinguished by causation: barren land (naturally occurring) and wasteland (anthropogenic). Desertification (United Nations 1994, 3) and the more general process of degradation (Tiffen *et al.* 1994, 14), however, can pertain to either natural or anthropogenic causation.
6. Elevational data derive from digital versions of INEGI 1:50,000 topographic maps: E14A19; E14B11; F14C89; F14D81.
7. Soils are given in accordance with the FAO (2006) classification system.
8. Caliche occurs in many of the world's semi-arid regions and often carries a local name. Some of these names are calcareous laterite (Australia), caprock (USA), tosca (Spain), and calcicrete (United Kingdom) (Goudie 1973, 8). Williams (1972) explores the semantic nuances and proveniences of the local terms for caliche within central Mexico.
9. In the vernacular of the American Southwest caliche can also refer to a desert clay soil (Michael 1988).
10. Calcareous alluvial material that descends in sheet erosion from higher elevations can also contribute to increased calcification within lower-elevation surface horizons (Marques de Silva and Alexandre 2004, 220-1; Solleiro-Rebolledo *et al.* 2006, 27).
11. Meteorological droughts are a normal and frequent feature of central Mexico's climatic regime not only as indicated by modern precipitation data, but also by the pre-Hispanic religious and agricultural practices of the Aztecs (Liverman 1999, 103).
12. These data were collected in Tula and Tizayuca, 20 km northwest and 12 km southeast of the study area, respectively.



## CHAPTER 4: THE PRE-HISPANIC INHABITED ENVIRONMENT

### Introduction

By 12,000 BP Palaeoindians had settled much of the Americas (Zeitlin and Zeitlin 2000, 62). Artifactual evidence points to the occupation of the study area by this time. In 1870, excavation work for a drainage canal unearthed evidence for the antiquity of human occupation of the study area – a mineralized sacrum of a camelid carved to resemble the head of a dog or coyote. Workers found it on the eastern outskirts of Tequixquiac in a bed of Late Pleistocene sediments at a depth of 12 m. Soil compacted within the carved nostrils matches the soil in which it was found and this dates it to between 12,000 and 10,000 BP. Now housed within Mexico City's National Museum of Anthropology and generally known as the "carved sacrum of Tequixquiac," this artifact is among the New World's earliest examples of art (Aveleyra Arroyo de Anda 1964).

The descendants of those who fashioned the "carved sacrum of Tequixquiac" dramatically altered the region's natural environment. Within Mesoamerica generally and central Mexico in particular, domestication and cultivation of certain plant species led to permanent agricultural settlements with complex systems of irrigation and terracing (Armillas 1949; Doolittle 1990). Over time, there arose various religio-political hierarchies and long-distance trade networks. This chapter focuses on how the rise of regional power centers, such as Teotihuacán and Toltec Tula, influenced the study area's demography and land-uses. I then discuss the study area's cultural ecology, especially as it concerns cultivated vegetative species and agricultural terracing. Together with the previous chapter on the natural environment, this chapter helps to establish the socio-cultural and environmental contexts for the first decades of Spanish pastoralism.

## Demography and Political Organization

As in the rest of Mesoamerica and the wider North American continent, around the dawn of the Holocene the Palaeoindians of the study area witnessed the extinctions of taxonomic orders of megafauna. Through the diffusion of domesticated plants – primarily a maize, beans, and squash complex – they gradually incorporated more vegetal components into their diet. These species were probably cultivated in the earliest settlement that archaeologists have found in the study area. The earliest so far identified is a hamlet (<100 people) 4 km due west of Cerro de Aranda that dates from the Late Formative Period (650-300BCE) (Sanders *et al.* 1979, map 11). Settlement growth in the area was slow and by the Late Terminal Formative (100BCE-150CE) there were only three hamlets in the area (Sanders *et al.* 1979, map 13). In the Classic Period (150-750CE) the efflorescence of nearby Teotihuacán precipitated a dramatic rise in the population in the northern half of the Basin of Mexico. These were Otomí peoples and they persisted throughout the rest of the pre-Hispanic era and into the Early-Colonial Period as the Valle del Mezquital's dominant culture group (Paso y Troncoso 1905 v. 3, 48, 53, v. 6, 13; Motolinia 1949, 81; Fournier 1998, cited in Fournier-García and Mondragón 2003, 50). The study area's demographic growth stemmed from its role as a major source area for the lime used in the large-scale construction projects at Teotihuacán. Within the study area's archaeological record for this period Sanders *et al.* (1979, 126-7) identify a close spatial association between settlement location and lime production:

Today there are several major cement plants in the region. These exploit the large lime deposits, of Cretaceous age, that outcrop so abundantly in this corner of the Basin. Many of our Middle Horizon [300-750CE] sites are in the Rio Salado drainage where substantial lime deposits have been cut into and exposed at the ground surface. Considering the massive use of lime plaster at Teotihuacán, it would seem reasonable that the Teotihuacanos settled the population in this area in response to that need. The association of sites with major lime deposits is very close, even to the degree that larger sites are found near major extrusions and small sites close to the

smaller ones. We did notices very heavy concentrations of limestone rubble in the fields of those sites located within a kilometer of the lime quarries, suggesting that the material was quarried, transported to, and burned in kilns within the village.

During the Epiclassic Period (750-950CE) Teotihuacán's decline led to a population reduction of ~14 percent (6,400 to 5,500) in the study area's vicinity (Parsons 1989, 191). This correlation supports Sanders *et al.*'s (1979, 131) speculation that the region was a lime resource center for Teotihuacán. They support their hypothesis by noting that during this period settlements were no longer adjacent to limestone outcrops. Even though the study area experienced a reduction in its total population a small "regional center" was established atop Mesa Grande's northern half (Sanders *et al.* 1979, map 15). This settlement might have been a component in a larger Basin-wide city-state system that existed in the temporal interstice between the apogees of Teotihuacán and Toltec Tula (Charlton and Nichols 1997, 169-70).

By the Early Postclassic Period (950-1150CE) Toltec Tula was at its height of influence within the southern Valle del Mezquital and northern Basin of Mexico. Owing to its proximity to Tula the study area and its environs saw a drastic demographic expansion of ~191 percent (5,500 to 16,000) (Parsons 1989, 197). In this period Mesa Grande's aforementioned "regional center" was abandoned, superseded by "large nucleated villages" of 500 to 1,000 people on Mesa Grande's lower slopes (Sanders *et al.* 1979, map 16). Parsons (1989, 199) hypothesizes that the abandonment of the better-fortified position atop Mesa Grande indicates centralized control emanating from Tula. Sanders *et al.* (1979, 140-1) remark, "Here areal population density was exceeded only by that of the Teotihuacán Valley. Furthermore, the proportion of population living in nucleated communities was the highest in the entire Basin of Mexico." Although Tula had its own lime quarries, the region's demographic growth is likely connected to lime production, as it had been during the

ascendancy of Teotihuacán (Mastache and Cobean 1985, 289). The growth might also be attributable to its favorable location between the obsidian quarries in Pachuca to the east and Tula to the west; at its height Tula imported 80-90 percent of its obsidian from Pachuca (Healan 1993, 454).<sup>1</sup> As had occurred in the wake of Teotihuacán's decline, Toltec Tula's demise as a power-center negatively affected the region's demography.<sup>2</sup> During this demographic collapse the abandonment proceeded to the extent that no settlements have been archaeologically identified that date to the subsequent Middle Postclassic Period (1150-1350CE) (Sanders *et al.* 1979, map 17).<sup>3</sup>

The area's demographic pendulum again swung upward during the Late Postclassic Period (1350-1521CE), eventually reaching approximately 41,000 by the period's close (Sanders *et al.* 1979, 214).<sup>4</sup> Dispersed villages were abundant (Sanders *et al.* 1979, map 18) and Gerhard (1993, 295) remarks that, "settlements were practically contiguous." Apaxco is the only modern settlement that existed before this period. It was established during the Early Postclassic Period, abandoned during the Middle Postclassic Period, and during the Late Postclassic Period resettled a few kilometers northeast of its original site.<sup>5</sup> It was not until the Late Postclassic Period that the rest of the study area's large modern pueblos were established (Sanders *et al.* 1979, maps 16-18). In the Early Colonial Period Spaniards began to call large native settlements with administrative power *cabeceras*. Each cabecera administered a small jurisdiction that often encompassed smaller settlements called *sujetos* (Gibson 1964, 33).

The Triple Alliance operated two spatially overlapping administrative hierarchies – tribute states (*tlahtocayotl*) and tribute provinces (*calpixcayotl*).<sup>6</sup> After mapping both of these hierarchies Hicks (1992) determined that their territories were far from coincident. He hypothesizes that this was purposeful in the interest of "exploitive efficiency." Aztec tribute

records show that the entire study area was wholly within a single tribute province with Hueyoptla as its administrative center (*Matrícula de Tributos* 1980, 32).<sup>7</sup> It was also entirely within the tribute state of Apaxco, which itself was subject to Tlacopan (Hicks 1992). Among other items, the study area appears to have produced lime as tribute payment in the Late Postclassic Period and into the Early Colonial Period (Paso y Troncoso 1940 v. 14, 118-9).

### **Cultural Ecology and Land-use**

In recent decades geographers have made exceptional progress compiling a body of literature to challenge the misconception that the pre-Columbian New World was lightly populated and little modified by indigenous culture groups (see for example Denevan 1970; Turner and Butzer 1995; Sluyter 1999). Europeans only settled much of North America many years after their diseases had preceded them and decimated native populations. This left many heavily modified environments to erode or become obscured by vegetation. Consequently, early European colonists mistakenly considered pre-Columbian North America a continent little transformed by indigenous peoples. The magnitude of this long-standing misconception about the North American landscape is still being investigated (see for example Denevan 1992; Doolittle 1992; Dods 2002; Deur and Turner 2005).

The Spanish conquistadors and early settlers who arrived in central Mexico encountered an indigenous population in the millions with a complex sociopolitical hierarchy and extensive agriculture. But what did not conform to their preconceived European notions of what the landscape ought to be like (that is, a European landscape) was oftentimes ignored or simply not recognized, and so escaped documentation (Mignolo 1995, 297). This includes substantial landscape modifications such as sloping field terraces in the Veracruz lowlands (Sluyter 2006), raised fields in Campeche (Siemens and Puleston 1972), and the

semi-terraces that hugged the gently sloping bases of many cerros (Rojas Rabiela 1991, 44-5).

The most extensive indigenous landscape modifications were for agricultural purposes. Sanders *et al.* (1979, 242-3) outline two forms of cultivation within the Basin of Mexico during the Late Postclassic Period: rain-fed (or *temporal*) cultivation and terrace cultivation. Temporal cultivation was practiced in humid bottomlands, most frequently in the Basin's southern half where sufficient precipitation allowed it. If springs or streams made it possible, temporal cultivation was usually augmented with canal irrigation (Doolittle 1990). Temporal cultivation was also practiced on sloping land, which Sanders and his colleagues (1979, 243) describe as "a rather casual kind of cultivation. . . characterized by low labor input, [and] low and variable productivity." Although agriculturalists also practiced temporal cultivation on hillslopes, it was more common for these locations to be cultivated with (semi)terraces. A terrace system is a cultural adaptation to slope cultivation intended to create a more level planting surface. A level surface slows down precipitation run-off, giving it sufficient time to percolate through the soil profile. This not only increases soil moisture, but also reduces soil erosion. The Basin of Mexico is representative of much of the rest of Mesoamerica regarding the occurrence of terraces – they are infrequent or absent where rainfall alone is sufficient for plant growth. This indicates that although terracing simultaneously increases infiltration and reduces soil erosion, it was the former function for which indigenous agriculturalists constructed them (Donkin 1979, 22, 34; Sanders and Murdy 1982; Miller 2007, 25).

But what landscape modifications did pre-Hispanic agriculturalists undertake within the study area? Because there is no extant description of this area of sufficient antiquity to answer this question, inferences must be drawn from wider regional contexts as well as mid-

sixteenth century Spanish landscape descriptions. Sanders *et al.* (1979, 243) believe the archaeological evidence for a dispersed housing pattern in the northern reaches of the Basin of Mexico in the Late Postclassic Period indicates that the region was heavily terraced at Conquest. A dispersed housing pattern suggests a terraced landscape because cultivators needed to be near their terraces to perform regular maintenance on them (Sanders *et al.* 1979, 249; Evans 1985, 13). Potsherds and worked obsidian are dense on many of the study area's hillslopes (Figures 4.1 and 4.2). Additionally, rapid expansion of the area's Late Postclassic Period population likely required agricultural intensification that was realized through terracing on hillslopes (Smith 1996, 69; Berdan and Smith 2003, 241). Although the expansion of terracing into more marginal lands would have yielded a near-immediate increase in agricultural production, the hillslopes' eroding sediments may have congested irrigation canals and check-dams in the more productive humid lowlands. Terracing of marginal lands may thus have resulted in a longer-term overall agricultural decline (McAuliffe *et al.* 2001, 57). Whitmore and Turner (2001, 134) posit that many Mesoamerican terraces in use today had been constructed by 1519. They reason this because there would have been no need for additional terracing during the colonial period in light of the dramatic decrease in the native population.<sup>8</sup> However, recent archaeological work by Borejsza and colleagues (2008) in Tlaxcala indicates that a certain number of terraces there date to the colonial period, possibly built to reclaim degraded lands for commercial grain production.

Pre-Hispanic terracing within the study area can be inferred from its spatial and socio-political alignment with Toltec Tula. The Tula River valley was one of the most heavily terraced landscapes in pre-Hispanic Mesoamerica (Rojas Rabiela 1991, 85). In their archaeological study of the Tula area Mastache *et al.* (2002, 266) found that terrace construction began there during the Early Postclassic Period (950-1150CE) and that most of



**Figure 4.1.** Potsherds and obsidian flakes overlay thin soil near the former site of Tezcatepec



**Figure 4.2.** A dense array of potsherds litter the hillslopes 3/4 km E of Zacacalco



these terraces were reoccupied during the Late Postclassic Period (1350-1521CE) when the central Mexican pre-Hispanic population reached its zenith. As already mentioned, because it was a lime resource area for Tula the study area's population rose ~191 percent during the Tollan Phase and then reached its peak during the Late Postclassic Period. This population expansion would have desiderated agricultural intensification in the form of terrace systems. So although to date no archaeological investigations have been conducted on the study area's terraces, it seems likely that most terraces are of pre-Hispanic provenience.

Rarely do sixteenth-century Spanish landscape descriptions mention terracing in New Spain. It is curious why this is the case when it is clear that the region was heavily terraced by Conquest. One possible reason for the omission is that natives abandoned many terraces before Spanish chroniclers described the landscape (Rojas Rabiela 1991, 85). Another is that terraces were simply not within the purview of the Spanish colonial mind. Regardless of the reason, the absence of historical references does not prove the absence of terraces.

Terraces aside, when used judiciously early-colonial Spanish documents can provide valuable insights into the nature of the study area's pre-Hispanic cultural ecology. Knowledge can be gained about the more permanent aspects of agriculture, particularly irrigation systems and the suite of cultivars. The *Suma de Visitas* (hereafter *Suma*) date from the late 1540s and are among the earliest systematic landscape descriptions of the study area (Paso y Troncoso 1905 v. 1).<sup>9</sup> The *Suma* entries for Tequixquiac and Apaxco describe the indigenous peoples irrigating their fields in narrow swaths along the banks of the Rio Salado (Paso y Troncoso 1905 v. 1, 17-8, 207).<sup>10</sup> These two reports do not state which crops agriculturalists grew, but presumably this fertile irrigated land was planted to maize (Mastache *et al.* 2002, 268). The entry for Hueycoxtila explicitly states that that it lacked sufficient hydrological resources for irrigation, and that nopal and maguey (*Agave* spp.) were

important cultivars (Paso y Troncoso 1905 v. 1, 110).<sup>11</sup> The entry for the twin cabeceras of Tezcatepec and Tuzantlalpa relates that the land was “cold and dry without water.” These pueblos relied upon the rainy season to generate groundwater for human consumption and to stimulate vegetative growth. This indicates that the native agriculturalists did not have a reliable water source that permitted irrigation, and that crops were watered by precipitation alone. Both of these pueblos did, however, cultivate maguey along with maize and beans, the latter two species were probably grown in the humid bottomlands of the Cañada de Tezontlalpa (Figure 4.3; Paso y Troncoso 1905 v. 1, 217-8). For Tezcatepec, terracing is strongly suspected by the pueblo’s location at the foot of a large mountain (Paso y Troncoso 1905 v. 6, 32). The pattern that emerges from these four *Suma* entries is that maguey



**Figure 4.3.** Maize cultivation in the Salado de Hueypoxtla’s streambed, 1/4 km SE of Hueypoxtla. August 2006

cultivation is only mentioned for pueblos that lacked irrigation.<sup>12</sup> Presumably, pueblos with well-developed irrigation systems, such as Tequixquiac and Apaxco, were able to grow a sufficient quantity of seed crops that they were not as reliant upon maguey as a supplemental food source. This connection between irrigation and which crops pre-Hispanic farmers cultivated corresponds with Melville's (1994, 35) findings for the wider Valle del Mezquital.

To a significant degree, the study area's pre-Hispanic cultural ecology revolved around the cultivated plants maguey and nopal. Natives ate the nopal's leaves (*nopalito*) both raw and cooked and its fruit (*tuna*) was harvested annually around mid-August (Torres 1985, 113-5). A tuna has as many vitamins and minerals as other fruits except they are much higher in calcium (Villareal *et al.* 1964). The most frequently cultivated species is *O. ficus-indica*, which has few if any spines. Nopal can reproduce sexually but in the pre-Hispanic era cultivators often cut the plant's leaves in order to vegetatively grow a clone (Granados Sánchez and Castañeda Pérez 1991, 84-5). The maguey provided its cultivators with more uses than the nopal: its roasted stalk can be eaten as a famine food; fiber from its leaves can be spun for clothing and blankets (*Matrícula de Tributos* 1980, 32); the high-protein insects associated with maguey can be eaten (Conconi and Moreno 1979); rotting leaves could be used as fertilizer (Rojas Rabiela 1985, 157); and fermentation of the sap (*aquamiel*) produces the mildly alcoholic drink called *pulque* (Bruman 2000, 62). People in the Valle del Mezquital had consumed pulque in place of water from pre-Conquest times until the very near present (Carrasco 1950, 55). Motolinia, a Spanish missionary who arrived in New Spain in 1524, observed that the drink was "very nourishing and wholesome" (1949, 331). Indeed, within a diet of traditional Otomí foods pulque provides 48 percent of the vitamin C, 24 percent riboflavin, 23 percent niacin, and 20 percent iron (Anderson 1946, 888). Maguey tolerates

harsh climates and likely aided permanent human occupation of the *tierra fría* (Sauer 1941b) as well as semi-arid zones where annual precipitation is too unreliable for people to depend solely upon seed crops (Johnson 1977, 204).

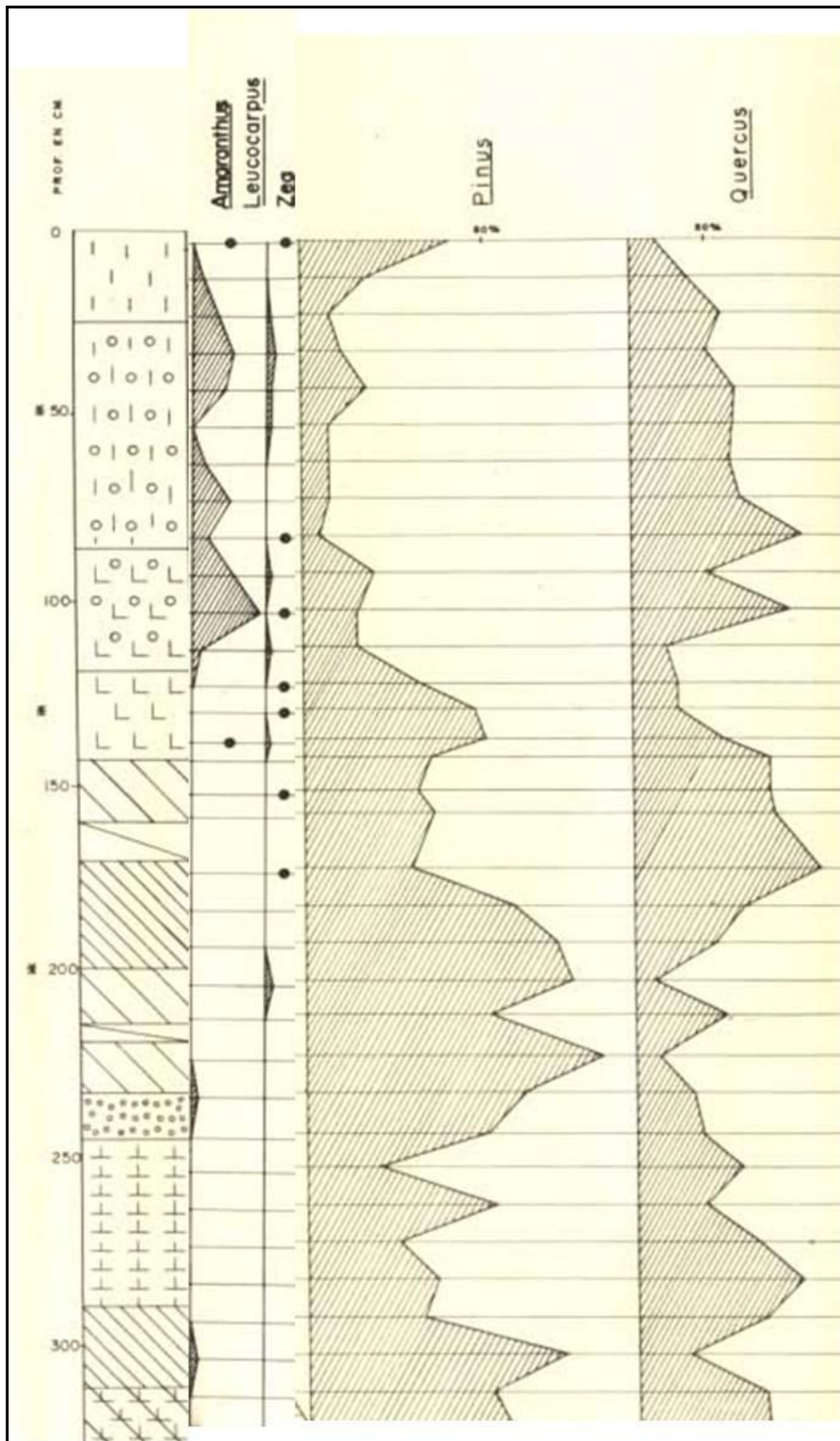


**Figure 4.4.** Metepantli semi-terrace on western slopes of Cerro de Aranda. August 2006

Many of the semi-terraces within the study area today – both still in use and defunct – are of a type called *metepantli* (Figure 4.4).<sup>13</sup> Metepantli are elongated semi-terraces that run parallel to the contours of the hill (West 1970, 364). The down-slope side of each field is lined with a berm. A single or double row of magueys along with other plant species are cultivated upon each berm. The maguey's lateral root system strengthens the berm and its wide leaves absorb the erosive impact of raindrops. The berms function as check dams that slow the downslope movement of precipitation run-off. This reduces soil erosion and allows

the water more time to infiltrate through the soil profile (Patrick 1985, 539-40). Metepantli fields are always dependent upon precipitation for soil moisture (Rojas Rabiela 1985, 190). The width of a metepantli field decreases as the slope's steepness increases because more berms are needed to control the run-off. Gentle slopes (5-10 percent incline) generally have field widths between 12 and 30 m. Steeper slopes (up to 25 percent incline) may have field widths of less than three m. Field length is limited only by that of the hillside, although they typically extend between 15 and 150 m (West 1970, 364, 367). In the sixteenth century, metepantli fields were likely planted to maize inter-cropped with beans (*Phaseolus vulgaris*), squash (*Cucurbita* spp.), and amaranth (*Amaranthus leucocarpus*) (McClung de Tapia 2000, 132).

Analysis of a pollen core taken from the Tula area reveals important insights about pre-Hispanic plant population dynamics (Figure 4.5; González Quintero and Montufar López 1980). This pollen core does not have defined dates but a chronology can be established by correlating socio-demographic phases with the peaks in maize. I concur with Butzer's (1992a, 148-9) reading of this core that the sustained high level of maize pollen between ~30-70 cm correlates with the high population of the Late Postclassic Period. I also agree with him that the double peaks between ~120-80 cm correlate with the ascendancy of Toltec Tula (950-1150CE). Where we diverge in our interpretations is that at the next lower peak for maize at ~140 cm he ascribes to the Late Terminal Formative (100BCE-150CE) introduction of maize into the Tula area. I, however, correlate this peak with the influence of Teotihuacán over the northern reaches Basin of Mexico during the Classic Period (150-650CE). The introduction of maize I correlate with the initial appearance of maize in the pollen record at ~200 cm.<sup>14</sup>



**Figure 4.5.** Tula pollen core diagram (González Quintero and Montufar López 1980, Diagrama Polínico No. 1")

During the Medieval Warm Period oak (*Quercus* spp.) expanded its range at the expense of pine (*Pinus* spp.). The subsequent cooler temperatures of the Little Ice Age then caused the situation to reverse.<sup>15</sup> Mastache *et al.* (2002, 255-60) believe this pollen core reveals a heavy reliance on cultivated amaranth (*Amaranth leucocarpus*) as a basic food during pre-Hispanic times. Amaranth appears to have been cultivated in the area before maize but subsequently it alternated with maize as the dominant crop until they coexisted at similar levels in the Late Postclassic Period.<sup>16</sup> To underscore amaranth's importance in the Tula area pre-Hispanic cultural ecology Mastache and her colleagues (2002, 258) write, ". . . it has greater resistance than maize to drought and frost, high potential yield in soils of different qualities and characteristics, the ability to be stored for long periods of time without spoiling, and especially that it has high nutritional value – permit us to propose that, in the Tula area, amaranth could have been as important a crop as maize, or perhaps even more important in drought situations."

### **Conclusion**

For millennia indigenous peoples have manipulated the Valle del Mezquital's natural environment to such a degree that it is not particularly insightful to think of a "natural environment" that persisted long after the arrival of humans. Instead, from the first appearance of humans until the Conquest it has been more practical to reflect upon the "pre-Hispanic inhabited environment." This is the physical environment and social milieu into which Spaniards introduced their system of agropastoralism and land tenure.

The rise of nearby regional power centers, such as Teotihuacán and subsequently Toltec Tula, carried great influence of the study area's demographic and economic trends. When those centers effloresced the study area became an important supplier of the lime used in their building projects. In this way, conditions external to the study area impacted its



land-use and population density. Agricultural terracing expanded when the population density peaked in the Late Postclassic Period. For whatever reasons, European chroniclers often failed to record these significant landscape modifications, not just in the study area but within much of the New World. Terracing within the study area can be inferred both from archaeological lines of evidence that point to a dispersed housing pattern and the high occurrence of archaeologically-confirmed terracing in neighboring Tula. Metepantli semi-terraces persist within the study area, many of which likely have a pre-Hispanic provenience. The humid bottomlands were not terraced but rather were irrigated with the Rio Salado's water in order to secure a reliable crop.

#### End Notes

1. Geochemical analysis can identify the sources of obsidian (Healan 1993, 449) and permit a reconstruction of Mesoamerican obsidian trade networks (Braswell 1993).
2. Drought-induced famines in the twelfth century might have triggered the collapse of Toltec Tula as well as the southward migration of the Mexica (Aztec) peoples into the Basin of Mexico (Metcalf 1987, 215).
3. Although the study area's population dropped to very low levels after Toltec Tula declined, further south in the Basin of Mexico the Aztec city-state system (*altepetl*) began to develop and would persist into the Early Colonial Period (Lockhart 1992, chapter 2; Berdan and Smith 2003, 238).
4. Borah and Cook (1969, 181-2) posit that highly productive domesticated food crops (the maize-bean-squash complex) combined with the absence of Old World diseases led to Late Postclassic Period's demographic explosion. They then suggest that the Aztec practice of ritualistic human sacrifice "looks remarkably like a response to population pressure." Harner (1977) echoes this by using "population pressure theory" to explain the "sociocultural evolution" of Aztec human sacrifice.
5. During their migration southward from Aztlán the Mexica sojourned for approximately 12 years in Apaxco among the Otomí before proceeding into the Basin of Mexico (Hernández-Rodríguez and Martínez García 2002, 60).
6. Member city-states of the Triple Alliance were Tenochtitlán (modern-day Mexico City), Texcoco, and Tlacopan (modern-day Tacuba) (Gibson 1964, 17).



7. All the study area's large Late Postclassic Period pueblos paid tribute to Apaxco. These pueblos were Hueycoxtila, Tlapanaloya, Tequixquiac, and Tezcatepec (Código Osuna 1947, 52).
8. It is possible that irrigation canals, such as the those in the Alcolhua province of Texcoco, serviced some of the study area's pre-Hispanic terraces (Wolf and Palerm 1955).
9. Even though they were written just thirty years after Conquest, I rely on the *Suma de Visitas* sparingly because it would be impertinent to assume that in those intervening three decades the landscape and cultural ecology had remained in their pre-Hispanic states. Accordingly, I only project back into the pre-Hispanic era the *Suma's* general descriptions of irrigation systems and cultivation of native plant species. Later primary documents, such as the *Relaciones Geográficas* and *mercedes*, are not brought into the current discussion because they postdate Conquest too much to well address the pre-Hispanic cultural ecology.
10. In addition to hydrating the soil irrigation was also a form of fertilization by nourishing agricultural fields with sediment in suspension and nutrients in solution (Rojas Rabiela 1985, 155).
11. Although many species of *Opuntia* bear edible fruit, most historical references to nopal probably indicate the most commonly cultivated species *O. ficus-indica*, and to a lesser extent *O. streptacantha* and *O. amyoclaea* (Granados Sánchez and Castañeda Pérez 1991, 13; Rojas Rabiela 1991, 131). The genus *Agave* has 136 species but the cultivated species of highland central Mexico known as "maguey" are usually *A. salmiana* ("maguey pulquero"), *A. salmiana*, *A. mapisaga*, *A. atrovirens*, *A. ferox*, *A. hookeri*, and *A. americana* (Mutada and Piña Lujan 1980, 30; Parsons and Parsons 1990, 2).
12. The *Suma* entry for the study area's sixth cabecera, Tlapanaloya, does not mention any aspects of the cultural ecology except that lime was abundant (Paso y Troncoso 1905 v. 1, 208). However, a complaint filed by native agriculturalist against Spanish ranchers indicates that livestock were eating and destroying maguey and nopal plants (AGNM v. 2 f. 97v.-98r.).
13. Metepantli is a Nahuatl word derived from *metl* (maguey) and *pantli* (row) (Karttunen 1992, 143, 187). Metepantli are sometimes also called "bancal" semi-terraces (West 1970, 361; Sanders *et al.* 1979, 245).
14. The explanation for my disagreement with Butzer over the interpretation of this core is that he cites "Figure 7" by González Quintero and Montufar López (1980). This is only a partial reproduction of their maize pollen data and does not display the earliest peak in maize pollen. The authors present their full dataset in "Diagrama Polinico No. 1."
15. Oak can grow in temperatures between 10° and 26° C. whereas pine can tolerate a wider range of temperatures between 6° and 28° C (Rzedowski 1978, 264, 285-6).

16. The pollen core diagram does well to depict the relative abundance of amaranth, but the absolute abundance of amaranth pollen relative to maize pollen is misleading because amaranth plants produce more pollen than maize (Mastache *et al.* 2002, 258).

## CHAPTER 5: SPATIAL ANALYSIS

### Introduction

This chapter presents the spatio-temporal reconstruction of land-granting in the environs of the sixteenth-century cabeceras Apaxco, Hueyoxtla, Tequixquiac, Tezcatepec, Tlapanaloya, and Tuzantlalpa. The concept of a “reconstruction” deserves attention. A reconstruction is not the same as a re-creation. “Re-creation” suggests a perfect image of historical reality, but for many reasons this is impossible to achieve. First, the completeness of archival collections is unknown (see Simpson 1952; Prem 1992a; Sluyter 1998). Second, the extant archival documents overwhelmingly reflect a male, governmental perspective to the exclusion of other historical actors (Adams 2003, 18-9). But the most basic problem is that every moment of historical reality would require a nearly infinite amount of data to re-create. Indeed, a “re”-creation would require perfect knowledge all the events that comprised the initial creation. A reconstruction, on the other hand, is an interpretation of the fragmentary and biased extant historical record (Hanlon 2001). For example, my spatio-temporal reconstruction of the study area’s estancias may differ greatly from that of another scholar who engages the same data sets. Similarly, in the future I may uncover more archival documents or gain a better interpretation of my data that will modify the current reconstruction. The “re” in “reconstruction” signifies these possible iterations.

The remainder of this introduction follows in two sections. In the first section, I contextualize this chapter within the emerging subfield of geography called historical GIS (HGIS). In the second section, I describe my approach to mapping colonial estancias. With some examples I explain what types of data lead to an accurately and inaccurately mapped estancia. Following the introduction I present and analyze various thematic maps of the study area’s estancias.

## Historical GIS

Geographers are increasingly finding that a GIS is able to analyze ethnographic, oral, and other qualitative data (Kwan and Ding 2008). HGIS studies also routinely use qualitative data because most archival data is textual (Knowles 2002, 452). A leading geographer in the field of HGIS is Anne Kelly Knowles, who expects an “exponential” increase in HGIS studies over the coming years (2008, 2). History may validate her expectation, if the number of publications on the topic is a reliable indicator. In 2002 she edited *Past Time, Past Place*, the first book devoted entirely to HGIS. The following year Gregory (2003) wrote a slender book for historians that introduces them to the most basic of GIS techniques. In 2005 Knowles (2005) edited an HGIS-themed issue of *Historical Geography* and in 2007 Gregory and Ell (2007) co-authored *Historical GIS*. By 2008 Knowles (2008) had edited a second book on HGIS entitled *Placing History*. Holdsworth (2002, 672) recognizes that HGIS may arouse feelings of uneasiness for those historical geographers who are suspect of positivist tendencies within their subfield. Knowles (2008, 267-8), however, frames HGIS as a bridge for intellectual connections to cross geography’s qualitative-quantitative divide.

Gregory and Ell (2007, 17) identify three main limitations of HGIS. First, archival sources often have incomplete or inaccurate data, and this becomes reflected in an HGIS’s sketchy database. Second, a GIS is not designed to incorporate temporal data. This makes data presentation and analysis tricky and necessitates creative solutions. Lastly, a GIS is not particularly well suited for qualitative data and so historical geographers must be innovative in how they incorporate textual analog data into a digital database. Gregory and Ell (2007, 184-5) soberly recognize that although a GIS can assess topologies and calculate a variety of spatial relationships, the onus remains with the researcher to “turn spatially-referenced data into knowledge about places.” In this chapter I create this type of knowledge by using socio-cultural data to explain many of the spatial patterns I find in the thematic maps.

### Cartographic Approach

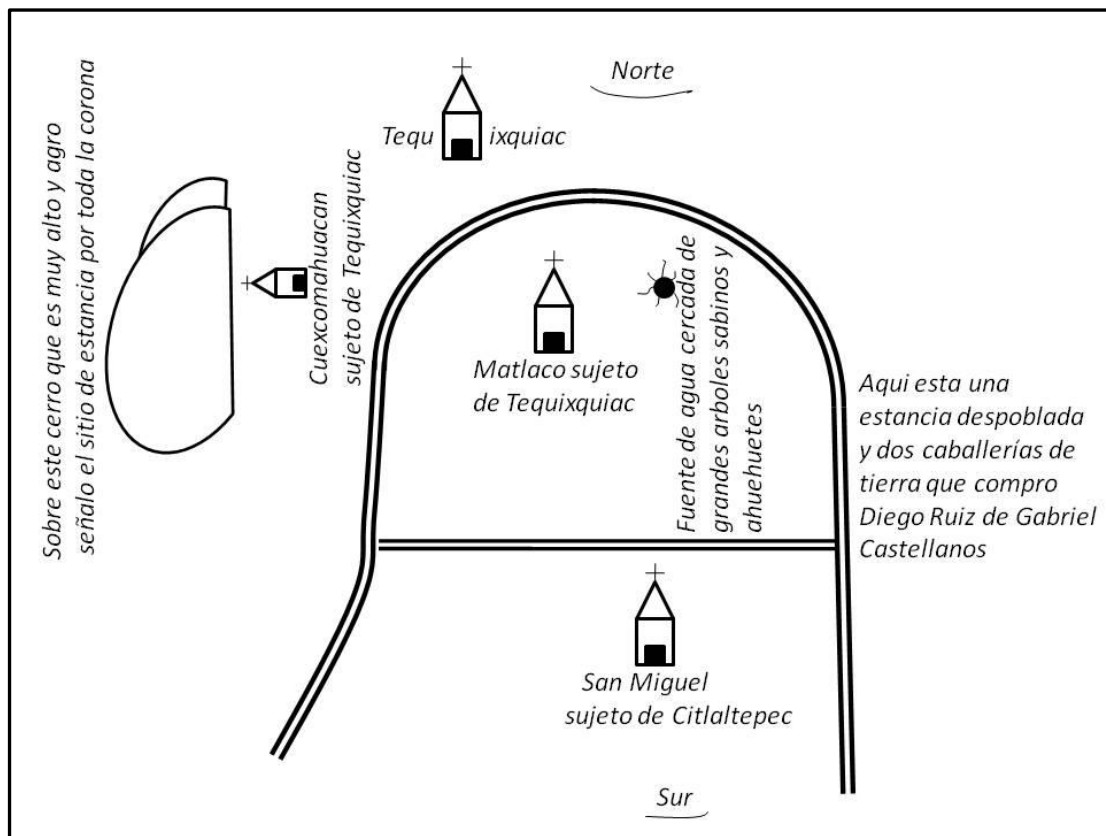
The current reconstruction is possible because estancias can be mapped, albeit with varying degrees of accuracy (see for example Barrett 1970, 115; Prem 1984, 208; Butzer and Butzer 1993, 91; Sluyter 1998, 511). Each grant applicant provided the locational details for the tract of land in question and, if the application was successful, then the viceregal scribes inserted this information into the merced. These details do vary greatly among mercedes, however. I estimate that I have mapped the centroids of 32 estancias with an accuracy of +/- 2 km. The remaining 15 I have mapped with less confidence within their respective cabecera jurisdictions (Appendix B).

Although I ostensibly use the mercedes' descriptions of estancia locations as they were intended, which is to locate them on the landscape, they are more difficult for me to interpret than they were for their authors and other contemporary interested parties. There are two reasons for this. First, the descriptions usually provide what Yao and Jiang (2005) term a "qualitative location." A qualitative location employs non-geometric spatial prepositions, such as "near" and "next to." More conducive to mapping are the spatial prepositions that invoke spatial relationships along Cartesian axes, such as "right," "left," or the cardinal directions (Landau 1996, 325). In these cases, the landscape can be thought of as a Cartesian plane and an estancia's center rests at point 0,0 on the plane. The presumption is that the top of the plane represents north so that for example the spatial prepositions "in front" and "behind" can be interpreted as "north" and "south," respectively. Likewise, "right" and "left" would mean "east" and "west," respectively (Vandeloise 2006, 141). With this Cartesian plane in mind, and through spatial reasoning more generally, it becomes possible to discern the topology of the study area's estancias.<sup>1</sup> For instance, if one estancia is described as "far" from another estancia, I can reason that the two estancias do not share a border or overlap. Similarly, a spatial relationship that uses the preposition "next

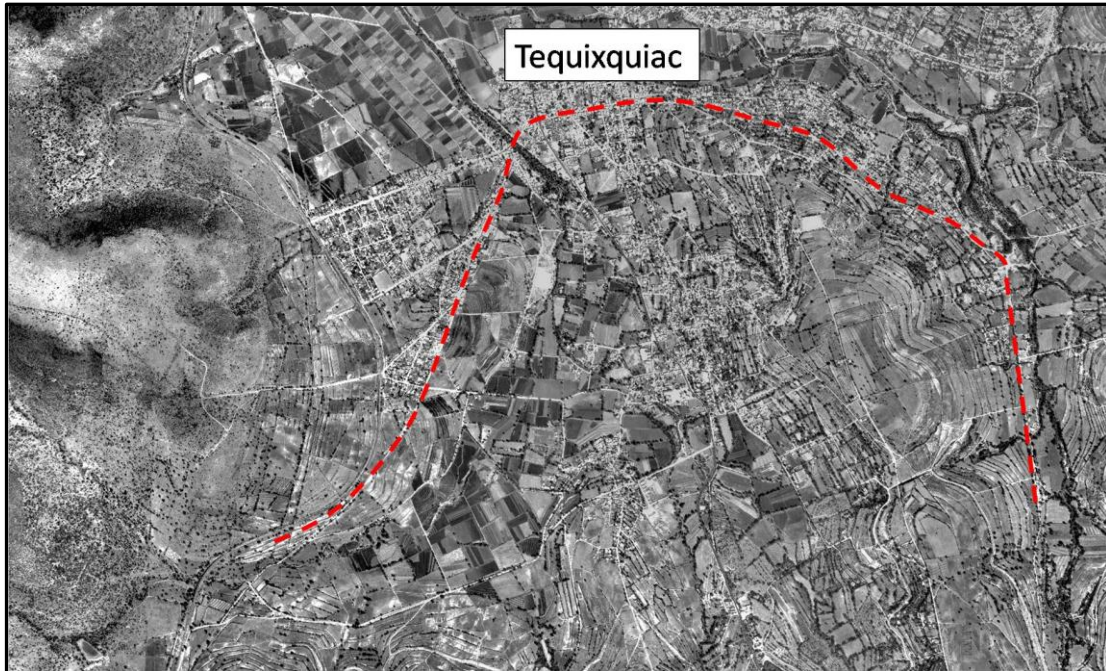
to” would indicate a shared boundary or two phenomena with high proximity (Renz 2002, 2-3).

Every location requires a frame of reference (Pinker 1997, 262). Each merced’s textual description of an estancia’s location employs socio-cultural and biophysical frames of reference that were current in the sixteenth century. This represents the second reason why their locational descriptions present me with difficulty – their frames of reference rely upon natural and cultural landscape features that no longer exist, or cannot be positively identified.<sup>2</sup> It requires archival and field investigations to identify as many extant features as possible (Sauer 1941a, 14). While conducting this work, however, one operates with a certain amount of what Harley (1989, 84) describes as “mimetic faith.” Endfield and O’Hara (1999b, 384) warn of the “unintentional warping of reality” when interpreting Spanish colonial documents. How such warping could occur is best described with the following scenario. In 1584 the Viceroy awarded an estancia near Hueycoxtila that is described as “on the skirt of a mountain called Aranda on the western side, near an old waterhole, about one and a half leagues from said town.”<sup>3</sup> The toponym Aranda remains current for Cerro de Aranda, and so this estancia can be fairly accurately mapped in a GIS. If, hypothetically, the toponym had been extinct and unidentified, then siting this estancia accurately would become significantly more difficult. In this situation, I would have to rely on its description as being one and a half leagues from Hueycoxtila, but this distance may be quite inaccurate (Bernal 1957, 289). If I failed to map this estancia on Cerro de Aranda, then reality would become unintentionally warped. The more accurately mapped estancias, then, are those with locational descriptions that include both geometric prepositions along with known toponyms.

A map accompanied each merced and their frames of reference are often towns, mountains, and other extant landscape features. However, few such maps are preserved for mercedes awarded in the study area. The maps that have survived, however, are quite useful for mapping estancias. For example, a map of the Tequixquiac area accompanied the merced awarded to Diego Mercado in 1591 (Figure 5.1).<sup>4</sup> This map also reveals the location of an estancia granted five years earlier to Gabriel de Fonseca, but by 1591 had been sold to Diego Ruiz.<sup>5</sup> A digital orthophotograph of the same area reveals that the bell-shaped road depicted in the merced's map still exists (Figure 5.2).



**Figure 5.1.** Map that accompanied a merced awarded in 1591 to Diego Mercado that depicts his estancia and that of Diego Ruiz (digital rendition by author based upon AGNT v. 2691 exp. 11 f. 9r.-v., MAPOTECA #1684)



**Figure 5.2.** Aerial imagery of the Tequixquiac area. Dashed line indicates position of the main roadway depicted in Figure 5.1 (Gobierno del Estado de México, digital orthophotograph number 184)

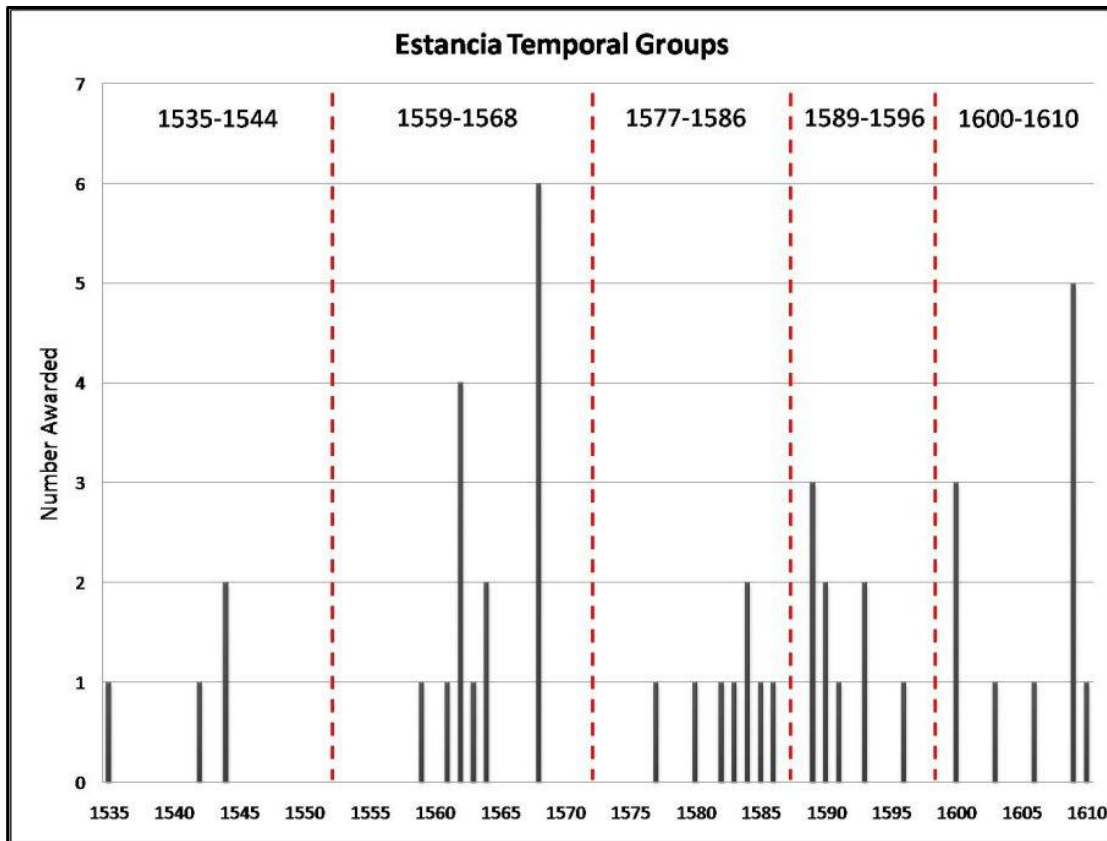
### Spatial Analysis

The study area's 47 known estancias are too few to yield a meaningful decadal analysis of spatio-temporal patterns. For instance, even though the mercedes date from between 1535 and 1610, I only have one merced from the 1550s and one from the 1570s. In order to identify and analyze the spatio-temporal patterns of land granting I have divided the entire granting period into five divisions based upon the temporal granting pattern (Table 5.1; Figure 5.3). Spatial analysis proceeds under these divisions.

**Table 5.1.** Division of estancias into five temporal groups

Year Group	Number of Mercedes for Estancias	Number of Estancias
1535-1544	3	4
1559-1568	15	15
1577-1586	8	8
1589-1596	9	9
1600-1610	9	11



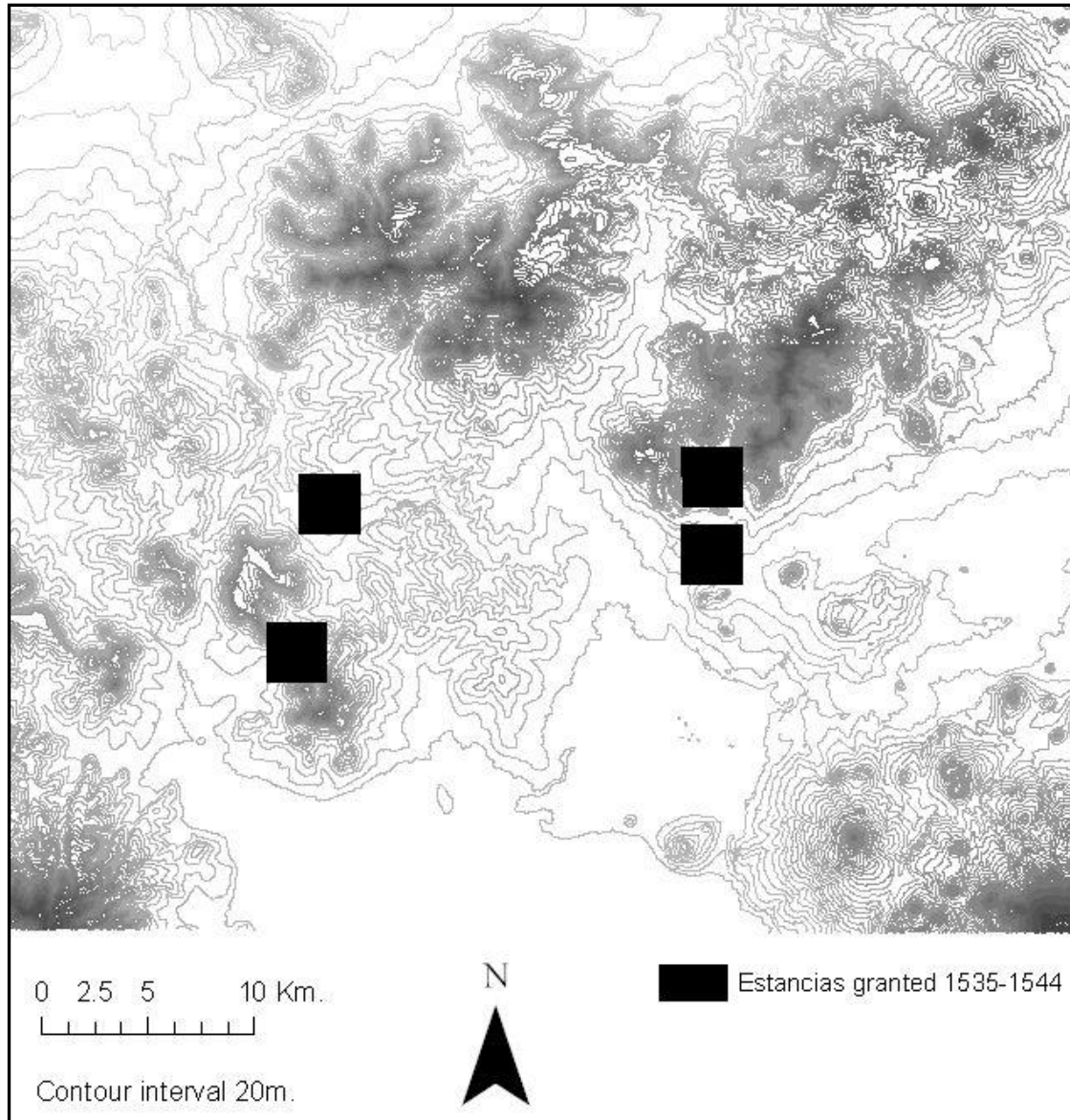


**Figure 5.3.** Estancia temporal groups discussed in this chapter

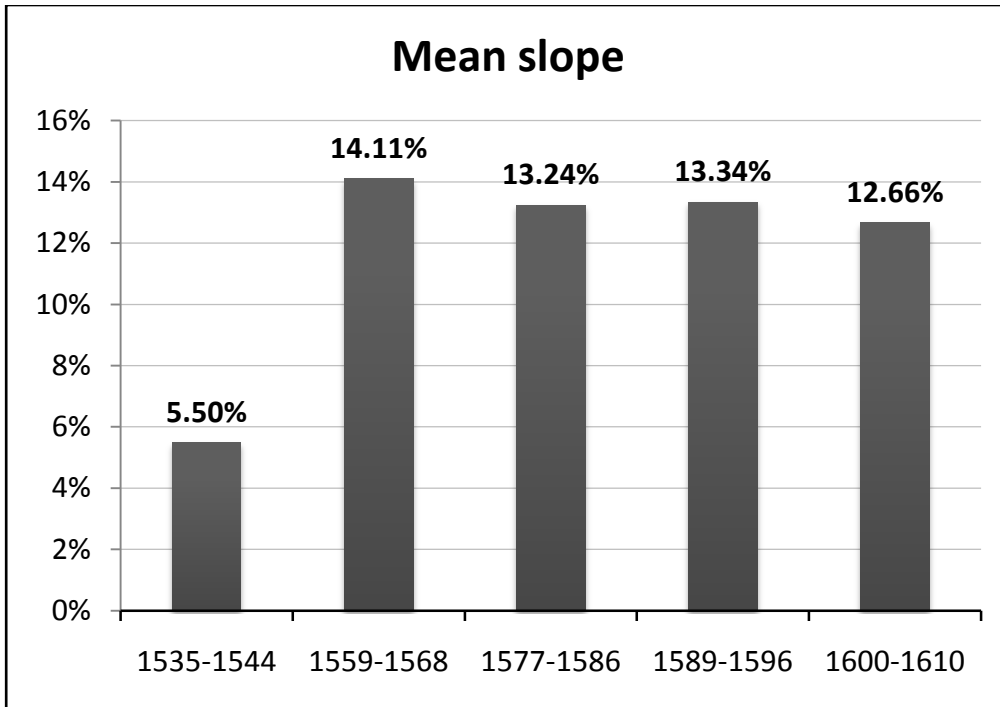
1535-1544CE

I have located mercedes for four estancias that date to this period (Figure 5.4). However, the two encomenderos who shared Tequixquiac, former conquistadors Martín López and Andres Nuñez, had registered their livestock brands in Mexico City in 1529. This indicates that they both likely ran livestock in the area of Tequixquiac prior to 1535 (Gardiner 1958, 94-7). The two easterly estancias belonged to Martín López and the two westerly estancias to Anton Bravo, the encomendero of Hueypoxtla and also a former conquistador (Paso y Troncoso 1940 v. 13, 37; Himmerich y Valencia 1991, 130, 184).<sup>6,7</sup> An encomienda did not entail land but encomenderos occupied an elevated social position for the Viceroy to award them mercedes more frequently than non-encomenderos (Gibson 1964, 275; Lockhart 1969, 416; Barrett 1973, 72). All four estancias occupied quite level, low-lying terrain compared to all

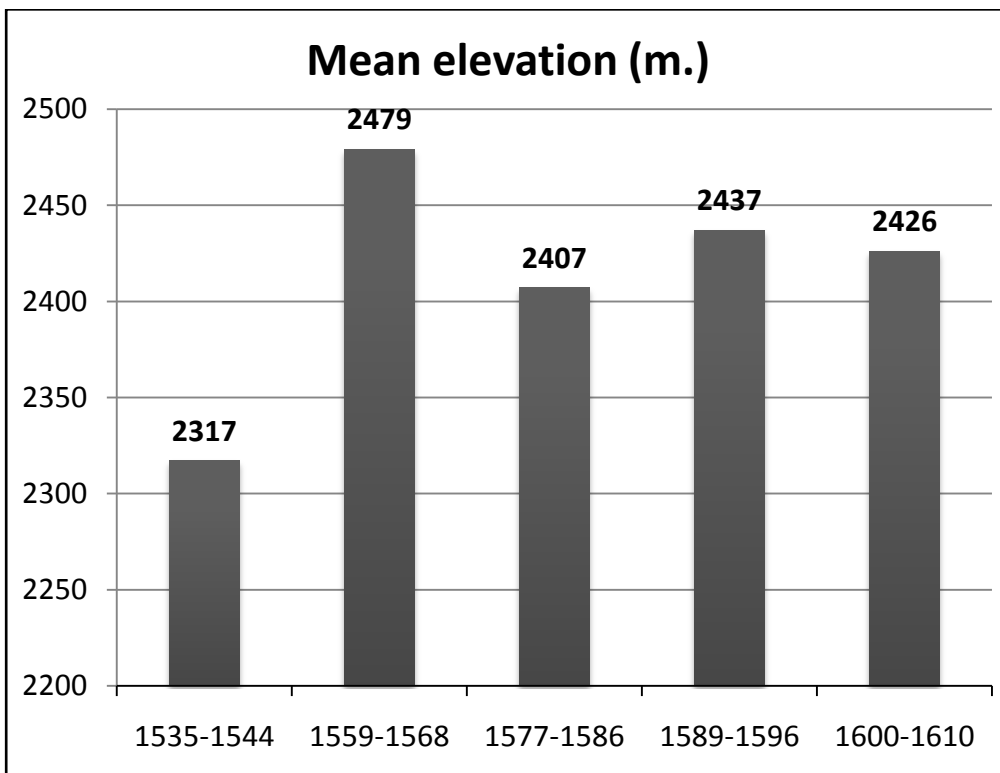
subsequent estancias awarded in the study area (Figures 5.5-5.7; Table E.1). This finding supports previous scholars' work in other areas of New Spain (Melville 1992, 148; Endfield *et al.* 2004, 226-7).



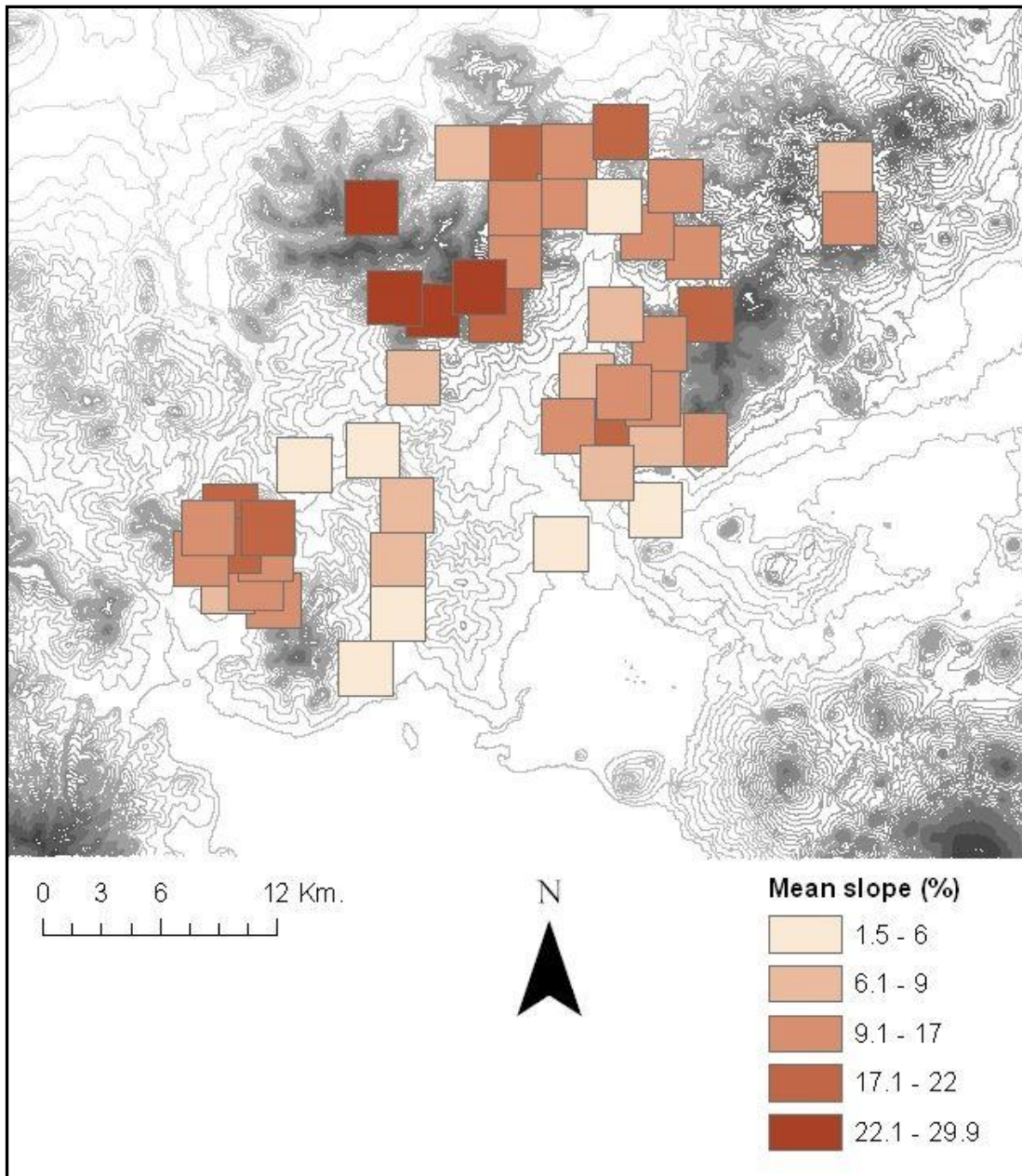
**Figure 5.4.** Estancias granted through 1544CE



**Figure 5.5.** Mean slope of estancia temporal divisions

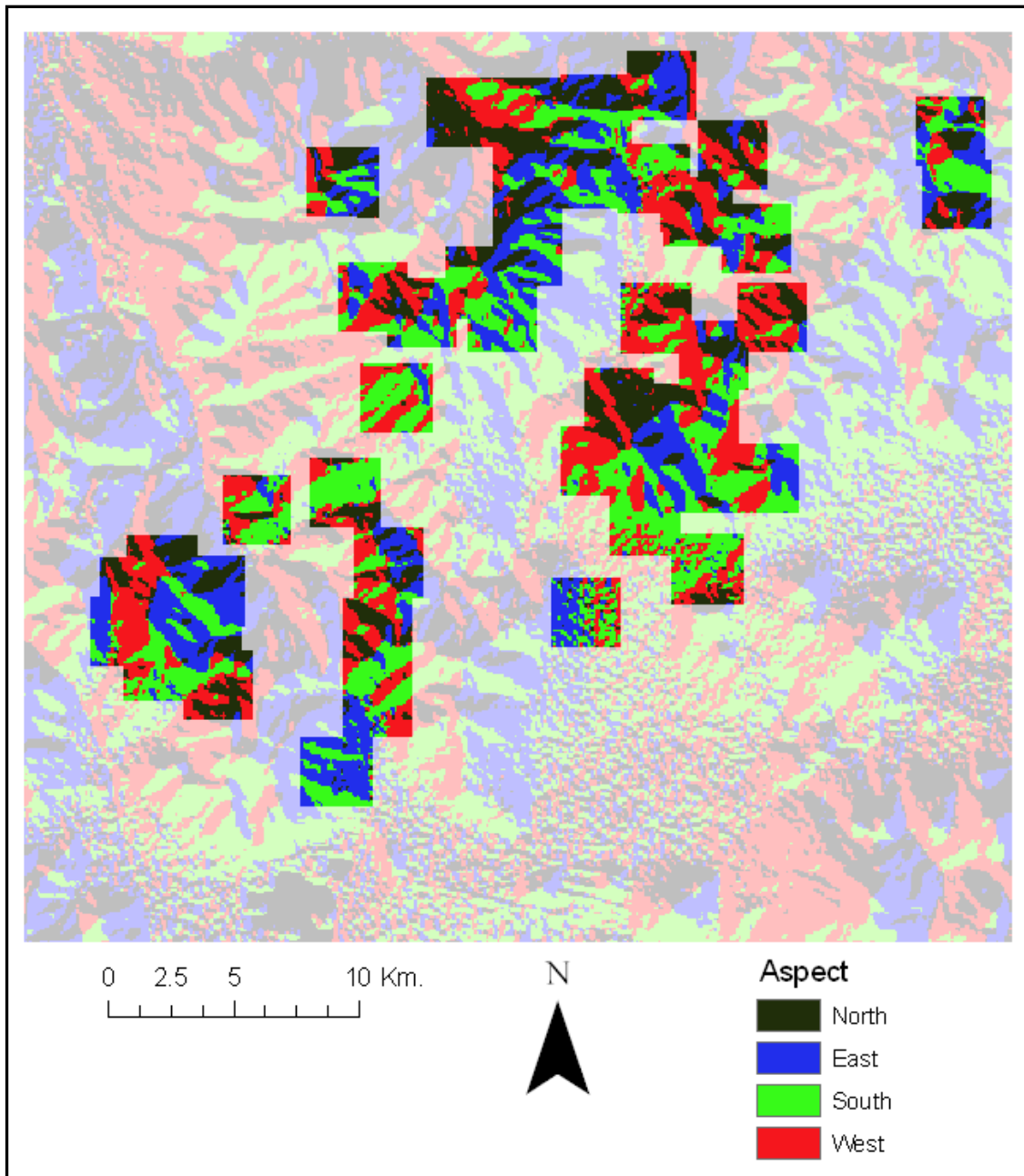


**Figure 5.6.** Mean elevation of estancia temporal divisions



**Figure 5.7.** Mean slope of the study area’s estancias

The aspect values of estancias can only be calculated by mapping them in a GIS. After mapping all of the study area’s known 47 estancias in a GIS, I used a digital elevation model to generate a raster image of aspect. Cell size in this raster image is 8.125 km<sup>2</sup> and each cell has a bearing degree value. For instance, cell values of 5 and 355 are both nearly due north, and 90 is due east. I categorized each cell value to fall into one of four the



**Figure 5.8.** Aspects of estancia lands

cardinal directions (Figure 5.8). I then categorized each estancia according the dominant cardinal direction of its cells values (Figure 5.9; Appendix B). The estancias awarded in this earliest granting period had the highest percentage of land with a southerly aspect (37.9 percent) and the lowest percentage with a northerly aspect (15.9 percent) (Figure 5.10). The



importance of a southerly aspect is that in the Northern Hemisphere a southerly exposure receives the most insolation. So it would appear that the earliest estancieros secured the most productive rangelands first. Of the study area's 47 estancias, 18 had a dominant southerly aspect and only 9 had a dominant northerly aspect.

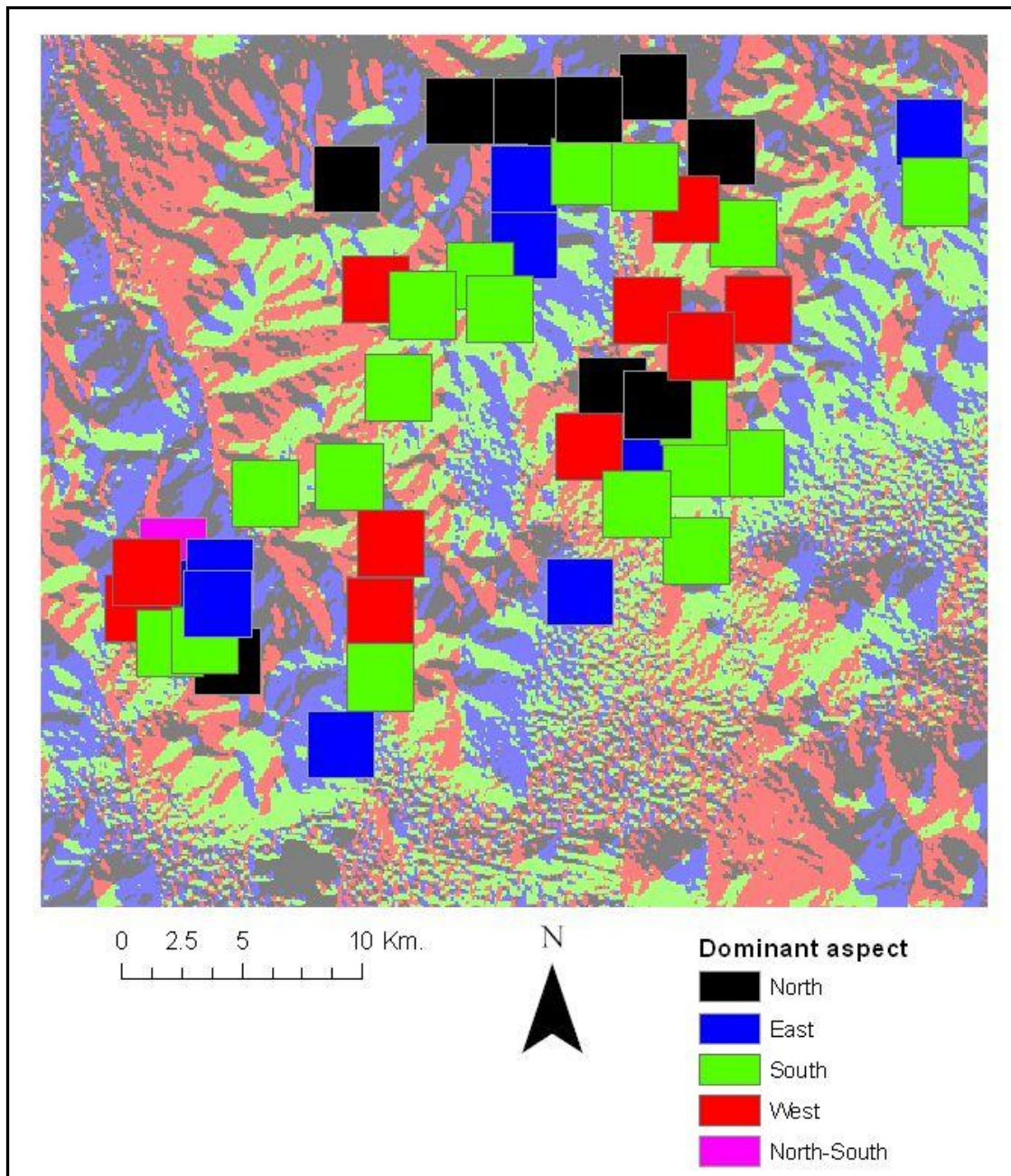
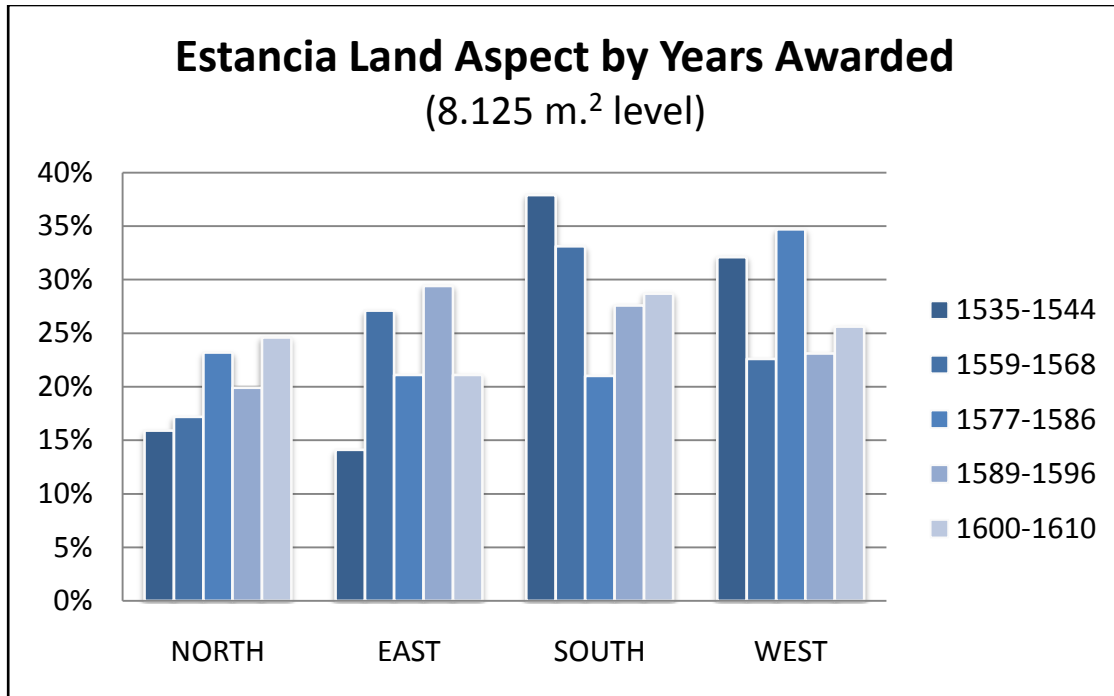


Figure 5.9. Dominant aspect of each estancia



**Figure 5.10.** Aspects of estancia land

#### 1559-1568CE

Just as in the pre-Hispanic era, in the Early Colonial Period the study area became an important source of lime (Kubler 1948 v. 1, 167; Gibson 1964, 336). In the Early Colonial Period, masons used burnt lime as mortar in stone construction. Throughout this period the importance of lime manufacturing increased in tandem with the increasing number of churches, convents, and Spanish homes being constructed. Some of the study area's lime was even trundled southward to Mexico City and the southern reaches of the Basin of Mexico, where limestone was rare or entirely absent (Gibson 1964, 335-6).<sup>8</sup> Borah and Cook (1958, 35-6) studied early-colonial lime transaction records and they calculate that the price of lime doubled in New Spain between 1559 and 1569. The profit motive behind lime burning in those years may help to explain why the study area's first two extant mercedes for caleras date to 1566 (Appendix A). Caleras soon after dotted the Sierra de Temoaya,



**Figure 5.11.** Calera in the hills east of Apaxco

especially north of Tlapanaloya and east of Apaxco (Figure 5.11). Hueypoxtla in particular became an important regional center of lime burning (Paso y Troncoso 1905 v. 6, 30; Gibson 1964, 336). The limestone hills that surround Apaxco are so rich in calcium carbonate that

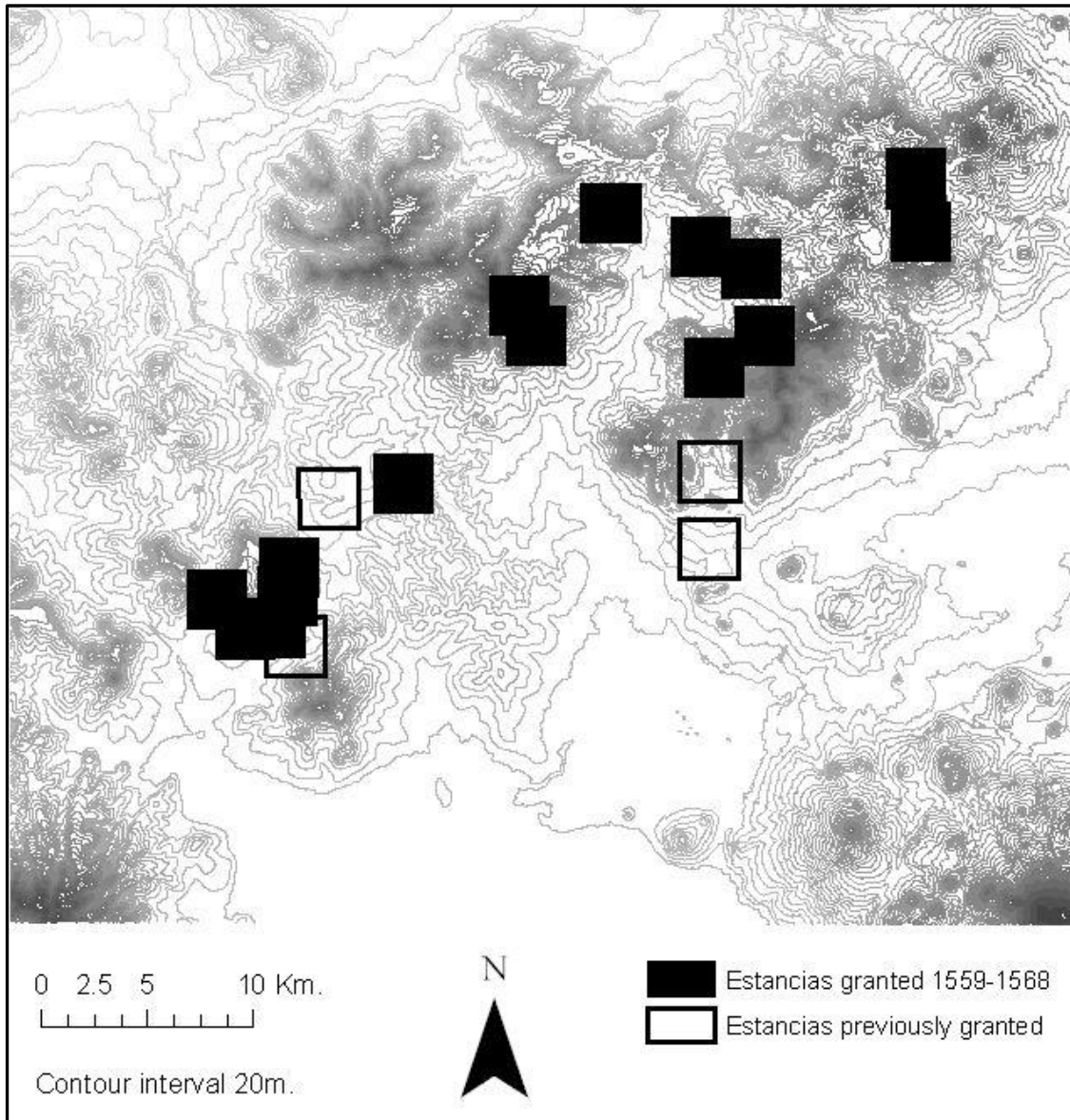


industrial-scale mining continues there today. Of all the study area's cabeceras it was Apaxco's early-colonial economy that seems to have been most reliant upon lime production. I infer this because for Apaxco I have located only one merced for an estancia but three for caleras (Appendix A).

Lime can be produced in either open-air bonfires or kilns. However, producing lime in a kiln allows greater heat retention and so burns wood fuel more efficiently (Russell and Dahlin 2007, 420). The presence of lime kilns in the study area, then, may suggest that wood fuel was a limited resource that needed to be conserved. Despite the greater efficiency of wood consumption provided by kilns, by the 1570s cutting wood to fuel the many lime kilns likely became a major cause of deforestation in the study area's northern hillslopes. Firewood had become scarce in the mountains by 1576 when Alonso de Aranda applied for a merced for a calera north of Tlapanaloya. The natives objected to Aranda's grant application on the grounds that his calera would deprive them of the firewood they needed for their homes and to fuel their own lime kilns.<sup>9</sup> Indeed, both Spaniards and natives owned lime kilns, and the latter group produced lime as a form of tribute payment (Paso y Troncoso 1940 v. 14, 118-9).

A landscape description of the Tlapanaloya area written in the 1540s describes much unoccupied land for sheep pastoralism (Paso y Troncoso 1905 v. 1, 208). The observation was prescient because the period 1559-1568CE experienced the greatest number of estancias granted in the study area (Table 5.1; Figure 5.12). These estancias have the highest average elevation and slope (Figures 5.5 and 5.6; Appendices C and D). The high slopes and elevations reflect the fact that 11 of the 15 estancias from this period were sited on hills (Table E.1). The relegation of estancias to hills was the intent of Viceroy Luis de Velasco (1550-1564CE) to shield native agriculturalists from the depredations of Spanish livestock

(*Recopilación* libro 4 titulo 12 ley 12; see also Chevalier 1963, 98-101). This group has the second highest percentage of lands with southerly aspects (Figure 5.10). This indicates that although these estancias were on marginal lands in terms of slope and elevation, they were still sited with favorable aspects.



**Figure 5.12.** Estancias granted through 1568CE

Melville's (1994, 136) purely textual analysis of mercedes for the entire Valle del Mezquital supports my mapping analysis that shows the grants from this period were in more marginal places away from native agricultural fields. That is, if high elevation and slope are reliable indicators of marginality. The one estancia of this group in a low-lying, level site the Viceroy had awarded to Melchior Cháves, Tlapanaloya's encomendero (Paso y Troncoso 1940 v. 13, 9). Cháves' status as an encomendero seems to have led to his acquisition of rather productive land at a time when the Viceroy awarded his contemporaries more marginal lands.

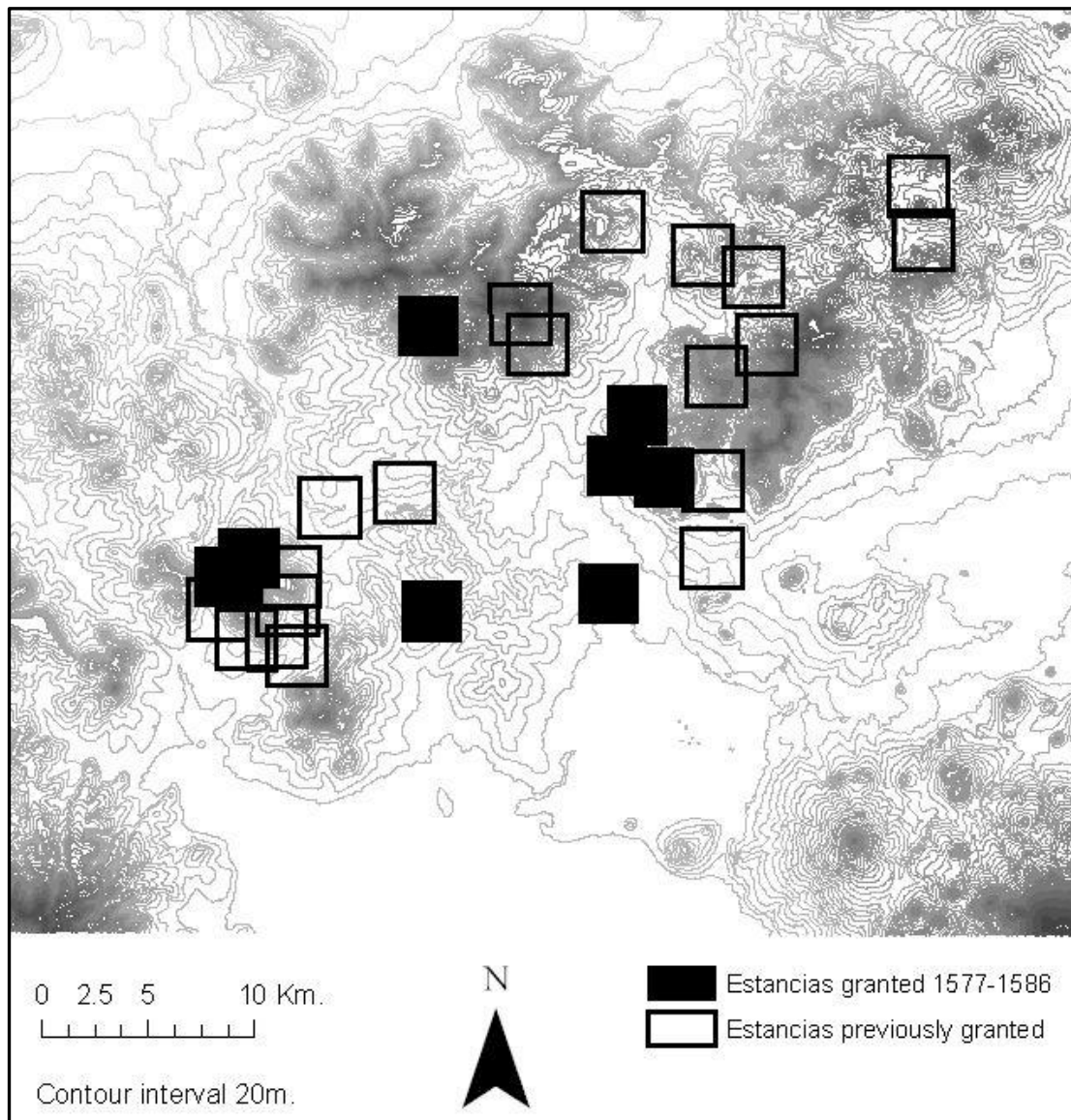
The earliest known mercedes for estancias to native communities in the study area date to 1568.<sup>10</sup> This rather late date might be explained by Poole's (1951) observation that land under crops sustains more people than land under pasture. Additionally, the capital investment required to stock an estancia may have left natives reluctant or unable to acquire estancias earlier. All five estancias granted to native communities in 1568 went to Tequixquiac. These estancias were tightly grouped on the central and southern portions of Mesa Grande, essentially forming a single, over-sized estancia.

#### 1577-1586CE

Between 1579 and 1581 the Spanish Crown sent to its overseas possessions a standardized questionnaire concerning the general social and biophysical environments. These collected responses are known as the *Relaciones Geográficas* (Paso y Troncoso 1905 v. 4-6; Cline 1972). The relación for Tequixquiac mentions watering holes, springs, irrigation, and many estancias (Bernal 1957). Tezcatepec's relación reports the area to have good pastures for sheep (Paso y Troncoso 1905 v. 4, 32). These pastures may have been well endowed indeed. In 1576 the natives of Tuzantlalpa wrote to the Viceroy that the 20,000 sheep on Juan Francisco de Sombrerero's estancia were damaging their sementeras.<sup>11</sup> Twenty-thousand is

likely an exaggerated figure, but there may be an element of truth in the assertion that sheep were numerous and damaging sementeras. The frequency of such damages may be indicated by a series of ordinances the Mesta passed in the 1570s meant to ease relations between agriculturalists and ranchers (see for example Ventura Beleña 1981, 21, 46-7, 54-5).

Six of the eight estancias from this period were sited on lomas (Figure 5.13; Table E.1). The preference for lomas may indicate the encroachment of estancias into land



**Figure 5.13.** Estancias granted through 1586CE

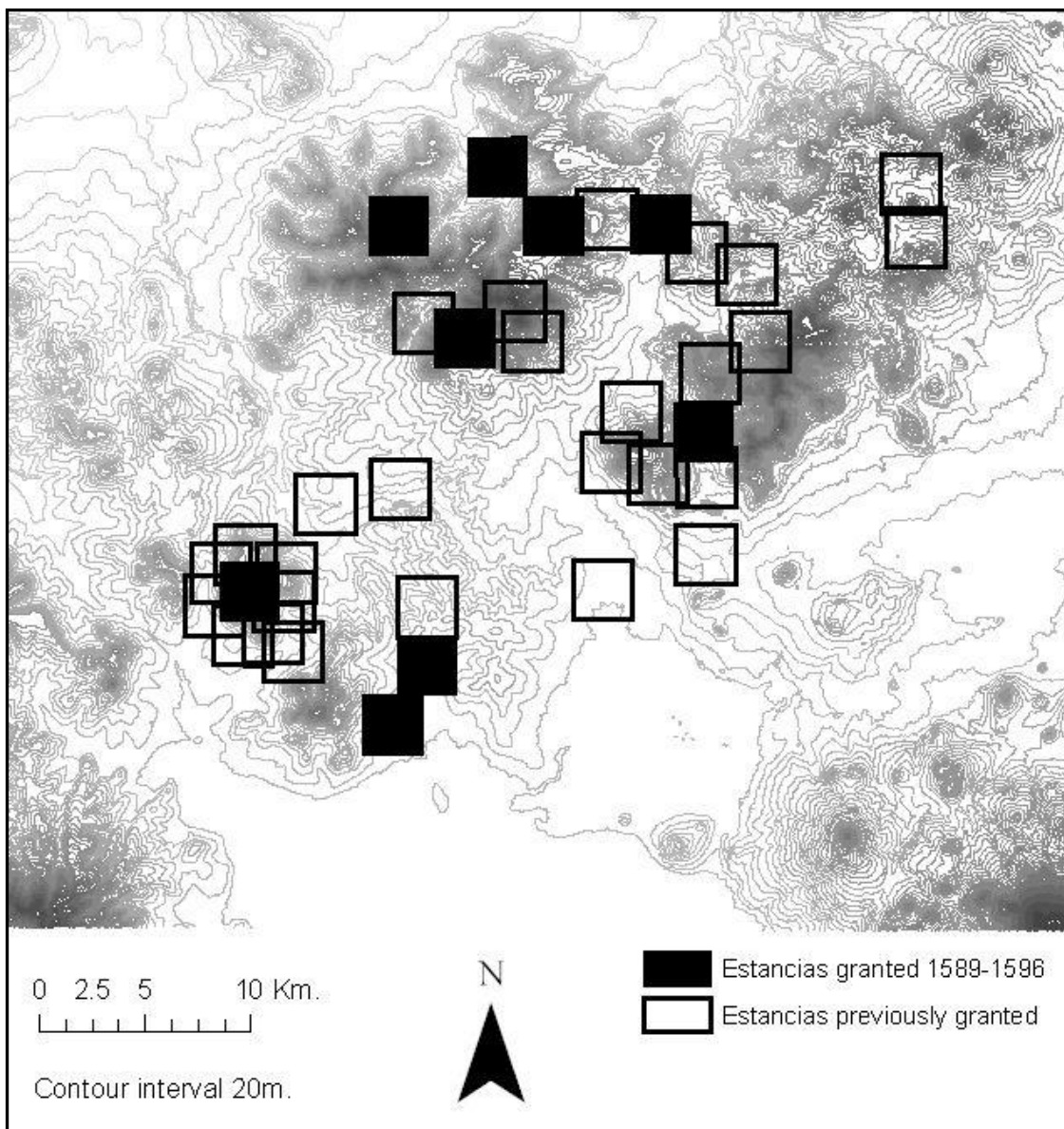
formerly under cultivation. Terraces recently abandoned may have provided the best pasturage (Fabila 1938, 115-6). An epidemic called “the Great Cocolistle” swept New Spain between 1576 and 1580 (Prem 1992b). In 1579 Tezcatepec and Hueypoxtla reported that the epidemic had greatly thinned their native populations (Paso y Troncoso 1905 v. 6, 30-2). The Great Cocolistle may have left some agricultural fields untended and free to be granted as estancias (Figure 2.1; Simpson 1934, 53; Borah 1951, 32-3; Prem 1992a).<sup>12</sup> For example, in 1586 the Viceroy granted a merced for an estancia within Tequixquiac’s jurisdiction.<sup>13</sup> The merced describes the estancia occupying a stony loma, next to a rock pile that appeared to the land inspector to be a small pre-Hispanic rock pyramid. On a loma southeast of Tequixquiac I found what may be the same rock pile (Figure 5.14). Here the abundance of obsidian flakes, potsherds, and worked stone is much higher than ambient levels.



**Figure 5.14.** A pre-Hispanic rock pyramid on a loma SE of Tequixquiac

1589-1596CE

Most of the eight estancias from this period occupied the hilly spatial interstices between preexisting estancias (Figure 5.15). The study area's first references to failing hydrology appear in two mercedes awarded in 1593 near Hueypoxtla. One merced records "dos jagueyes secos" and the other "quebradas secas" (Table E.5). Melville (1994) argues that desiccation in the Valle del Mezquital at this time was the result of sheep overgrazing (less



**Figure 5.15.** Estancias granted through 1596CE

vegetative cover and a more highly compacted soil decreased precipitation infiltration rates). Endfield and O'Hara's (1997, 258 and 1999a, 410) study of Michoacán's colonial environment has found that sixteenth-century references to failing hydrology and water disputes are associated with the sixteenth-century "megadrought" (Figures 2.8a and b; Stahle *et al.* 2000 and 2007). There is not a clear indication of drought within the rancher-agriculturalist litigation from this period. In 1591 along the Rio Salado's riverbank at Tequixquiac four sheep breeding paddocks (*ahijadero*) operated by local *estancieros* were leading to damages to surrounding sementeras. The landscape around the riverbank was described as forested and as having waterholes in the vicinity.<sup>14</sup> In 1596 around Hueyoptla a conflict arose between agriculturalists and pastoralists over water use during the summer growing season.<sup>15</sup> It is unknown whether possible drought conditions contributed to this social turbulence.

Reference to a "pedregalejo" near Hueyoptla in 1589 and a "barranca muy honda" near Tezcatepec in 1596 suggests the effects of extensive soil erosion were apparent on the landscape by this time period (Table E.2).<sup>16</sup> The presence of a large erosional feature, such as a barranca, indicates that sheet erosion was occurring for a number of years in this location prior to 1596 (Stocking 1978). It is also likely that a large number of rills went unreported that cumulatively transported more soil than the visually impressive barrancas transported (Córdova and Parsons 1997, 202).<sup>17</sup>

During the early 1590s Spanish officials carried out *congregaciones* to nucleate dispersed native communities and those people who lived scattered across agricultural areas into the *cabeceras* or new *pueblos*. The motive was to facilitate Catholic evangelization to the natives as well as more easily extract from them their labor and tribute (Gerhard 1977; Florescano 1987). *Congregación* was not voluntary and those who resisted could expect to

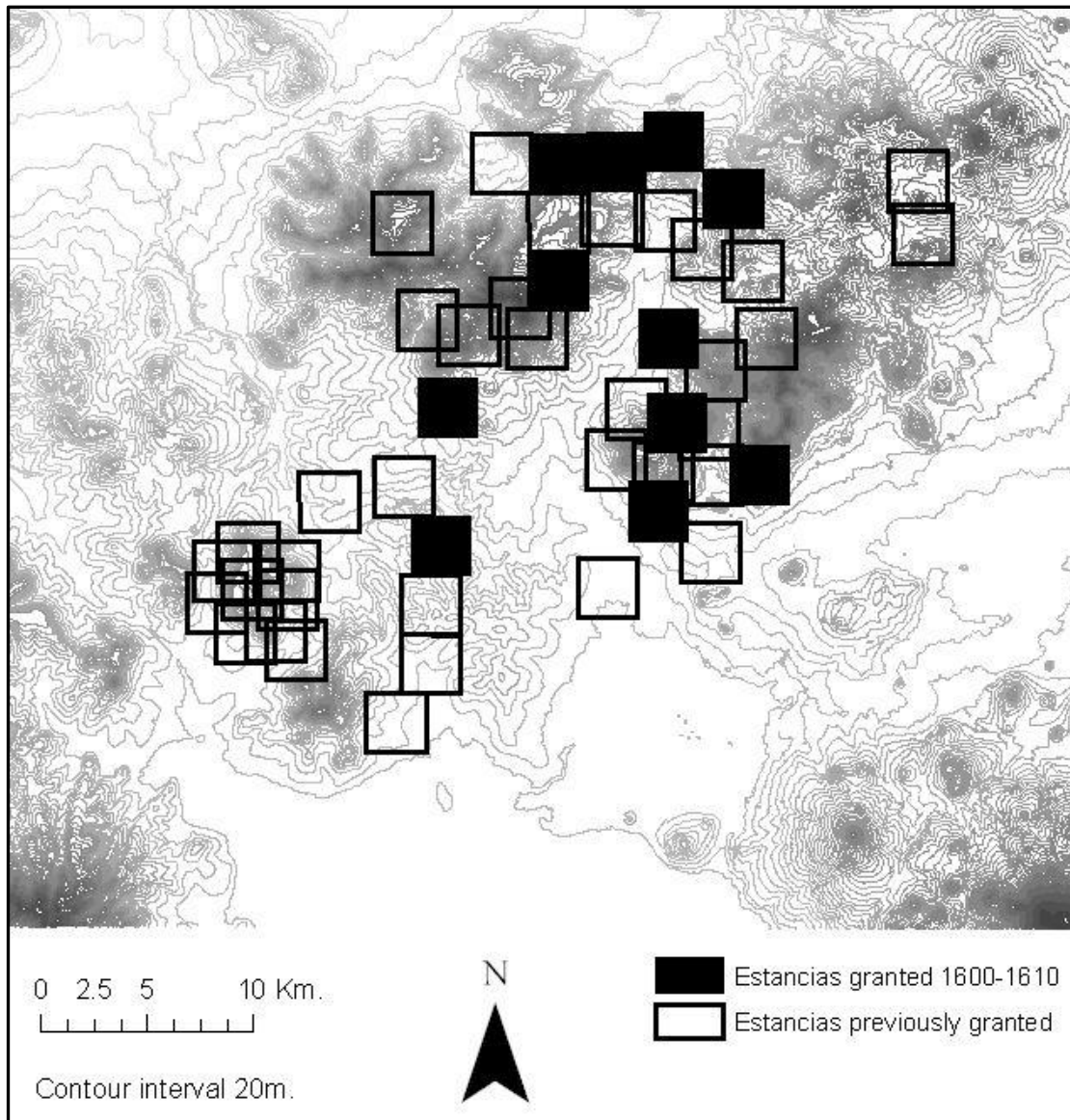
have their pueblos and homes burned to force their compliance (Moreno Toscano 1969, 77). In 1591 Xomeyuca, a subject pueblo of Tlapanaloya, was congregated to the cabecera.<sup>18</sup> Some natives tried to return to Xomeyuca but the Spaniards compelled them to remain.<sup>19</sup> In 1592 the natives who resided in isolated and mountainous lands subject to Hueypoxtla and Tequixquiac were also forced to relocate to their respective cabeceras.<sup>20</sup> The entire population of Tezcatepec was relocated to more accessible pueblos (Santa María Ajoloapan and Tianguistongo, both roughly 6 km south of Tezcatepec).<sup>21</sup>

As more natives became nucleated, more land was made legally available to distribute in mercedes (Simpson 1934, 53; Prem 1992a; Melville 1994, 144). But it was not only Spaniards who claimed these newly opened up lands. In 1593 the natives of Hueypoxtla received two mercedes for estancias in lands they had likely used only a short time before for agriculture. The mercedes describe wild maguey, abundant nopal, and capulin (*Prunus capuli*, a species of cherry) in these lands.<sup>22</sup> Another indication of prior agricultural activity is a map that accompanied one of these mercedes that depicts the estancia surrounded by sementeras.<sup>23</sup> The process may have been that as agricultural land contracted from epidemics and congregaciones the natives sought to maintain possession (by use-right) of their land through a more extensive land-use. This would agree with Melville's (1994, 150) observation for the wider Valle del Mezquital.

#### 1600-1610CE

This period's 11 estancias continued the previous period's pattern of filling in the intervening spaces among estancias (Figure 5.16). This period has the strongest indications of landscape degradation and desiccation. The only three estancias in the study area sited on quebradas date from 1600 and 1610 (Table E.1). In 1609 references appear in the mercedes to a "barranca grande" and an "arroyo hondo de tepetate" (Table E.2). Quebradas, barrancas,





**Figure 5.16.** Estancias granted through 1610CE

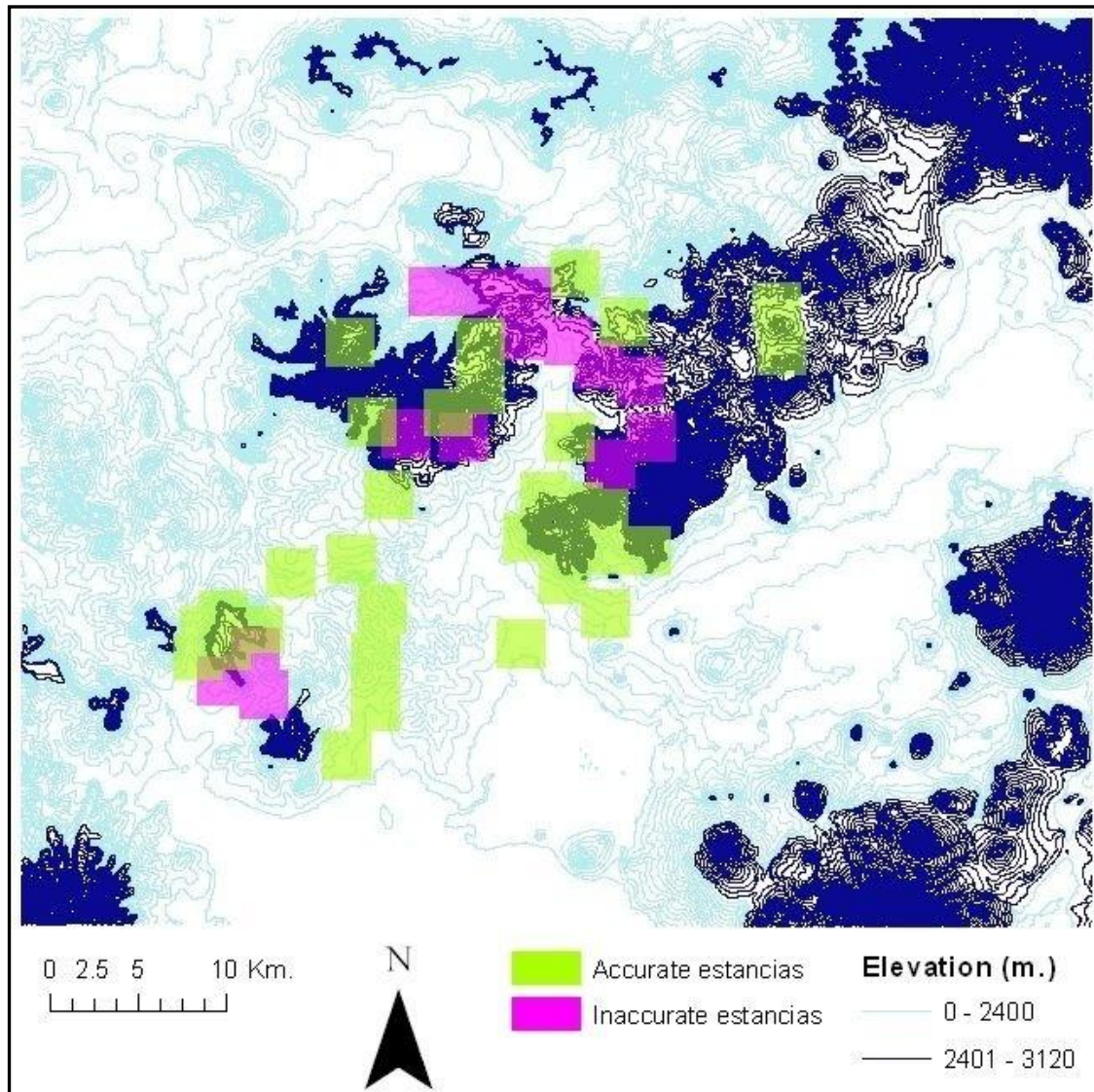
and caliche must reflect the effects of long-term, unchecked sheet erosion. Spiny plants, mesquite, scrub (*monte*), and pirul (*Schinus molle*) first appear in the mercedes' landscape descriptions (Table E.4).<sup>24</sup> In these years pirul and mesquite are mentioned in mercedes for estancias, which allows for a correlation between the vegetative species and the estancia's dominant aspect. The estancia with pirul has 43.2 percent of its area with a southerly aspect, and the estancia with mesquite has 54.5 percent of its area with a southerly aspect. Pirul is a

species often associated with disturbed and degraded environments (Muyt 2001, 253). However, pirul and mesquite may appear on the southerly tracts because the locally higher receipts of insolation, combined with regional climatic drying, may have produced exceptionally dry soil. The study area's mercedes contain six references to dry hydrological landscape features, and four of these references date from this period (Table E.5). As already mentioned, whereas Melville (1994) attributes archival descriptions of desiccation to the effects of sheep overstocking, Endfield and O'Hara (1999a, 410) suggest it is the expected result of drought conditions around this time. But sheep pastoralism and climatic drying are not mutually exclusive agents of desiccation.

#### Broader Spatio-Temporal Patterns

The study area's 47 known estancias tended to occupy zones of higher elevation (Figure 5.17). Again, this may reflect the intent of the Viceroy to protect the natives' agricultural lands from trespassing livestock. The preponderance of estancias in higher elevations may also reflect the likelihood that as the native population declined it was the more marginal agricultural lands that were abandoned first and granted as estancias (Denevan 1987, 31). Another clear spatial pattern is the tight clustering of estancias. Only four estancias did not border or overlap any other estancia. This clustering may in part reflect the successful efforts of Viceroy Martín Enríquez, who in 1571 disclosed, "I have taken care that the lands granted and divided up should link the various estates, continuously and *without intervening spaces of wasted land*" (quoted in Chevalier 1963, 102, emphasis added). The high-elevation clusters left agriculturally productive lowlands relatively free of livestock during the critical growing season. This supports Butzer and Butzer's (1997, 163) findings for the nearby Bajío as well as Barrett's (1970, 136) findings for Michoacán's Tepalcatepec lowlands. Estancias were not enclosed, however, so the spatial extent of each estancia probably exceeded the

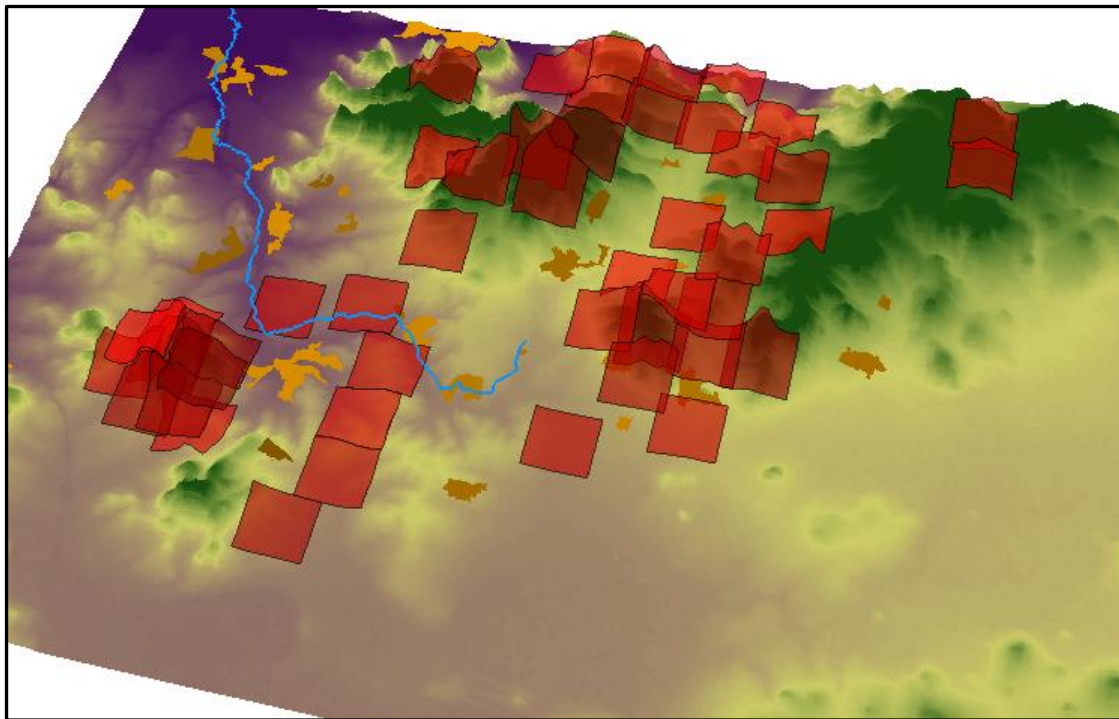
legally prescribed size and was more irregular than the legally prescribed shape. This would have been congruent with the Castilian custom of the time that granted the use of unclaimed land (*tierra baldía*) to those who placed it under cultivation or pasture (Vassberg 1974).



**Figure 5.17.** Estancias and elevational zones

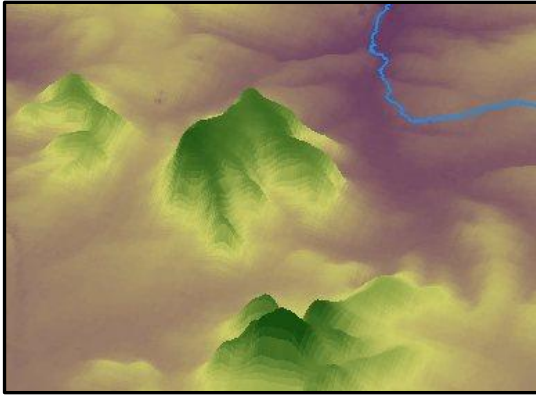
Estancia grouping and overlap were heaviest on mountains surrounded by low flatlands (5.18). This is best evidenced by Mesa Grande, immediately west of Tequixquiac in the study area's southwestern section (Figures 5.19a and b). Cerro de Aranda, northeast of

Hueypoxtla in the east-central section of the study area, also exhibits this pattern (Figures 5.20a and b). Mesa Grande and Cerro de Aranda are the only significant elevations within their respective cabecera's jurisdictions. The grouping of estancias on these elevations may underscore the conscious efforts of the Viceroy's to place estancias away from the natives' agricultural lands that were in the most productive zones. It may also indicate competition for the best pasturelands. Randell's (1979, 136) historical study of sheep stations in Victoria, Australia found that the stations overlapped on Mount Alexander, likely because of its open forest. Like Mesa Grande and Cerro de Aranda, Mount Alexander is surrounded by flatlands. In 1601 near Tequixquiac someone requested of the Viceroy an estancia less than half the prescribed size.<sup>25</sup> This might not indicate that the study area was severely congested with estancias but rather that space on Mesa Grande in particular was limited (cf. Melville 1994, 90).

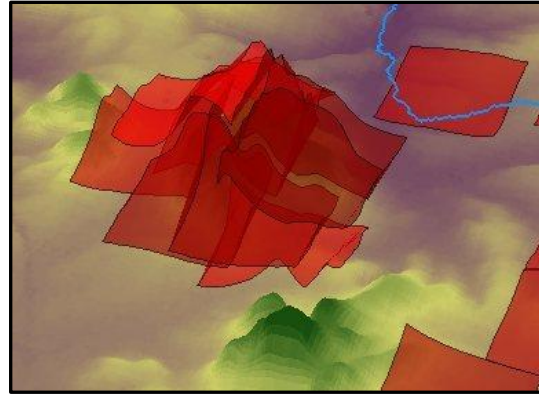


**Figure 5.18.** Oblique view of the study area's estancias, looking NNW

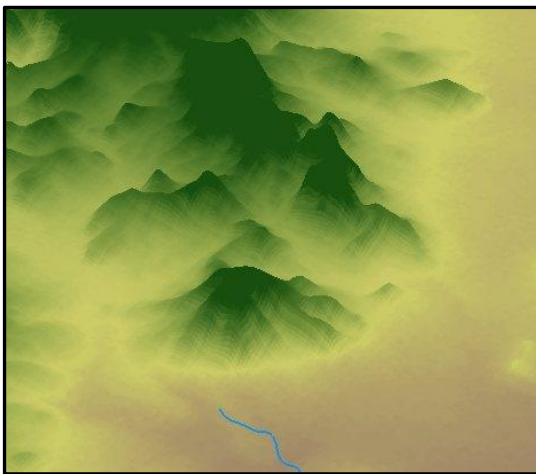




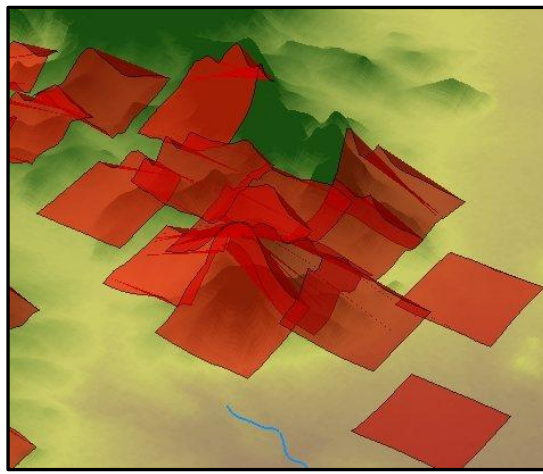
**Figure 5.19a.** Mesa Grande, center



**Figure 5.19b.** Mesa Grande with estancias



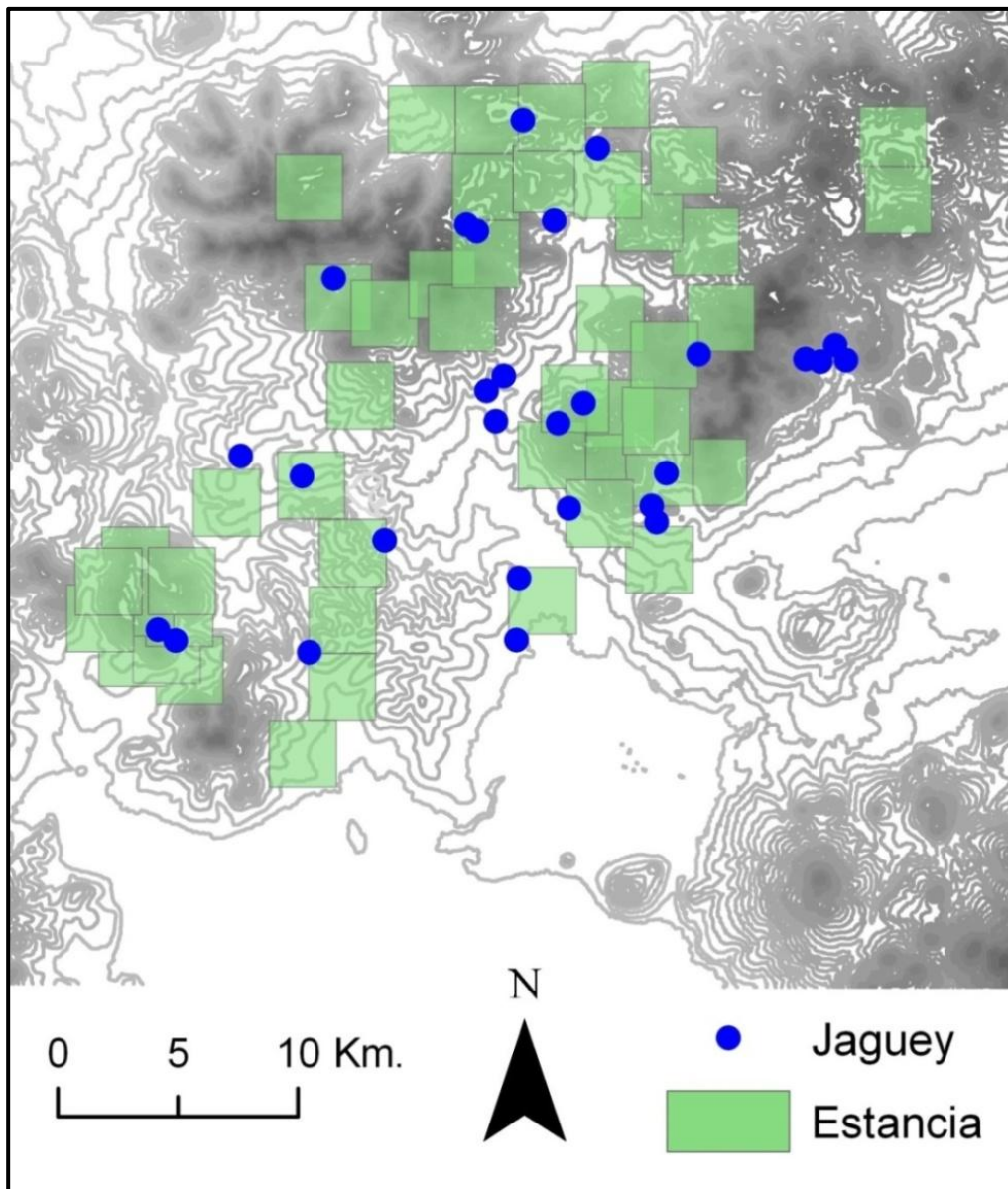
**Figure 5.20a.** Cerro de Aranda, foreground



**Figure 5.20b.** Cerro de Aranda with estancias

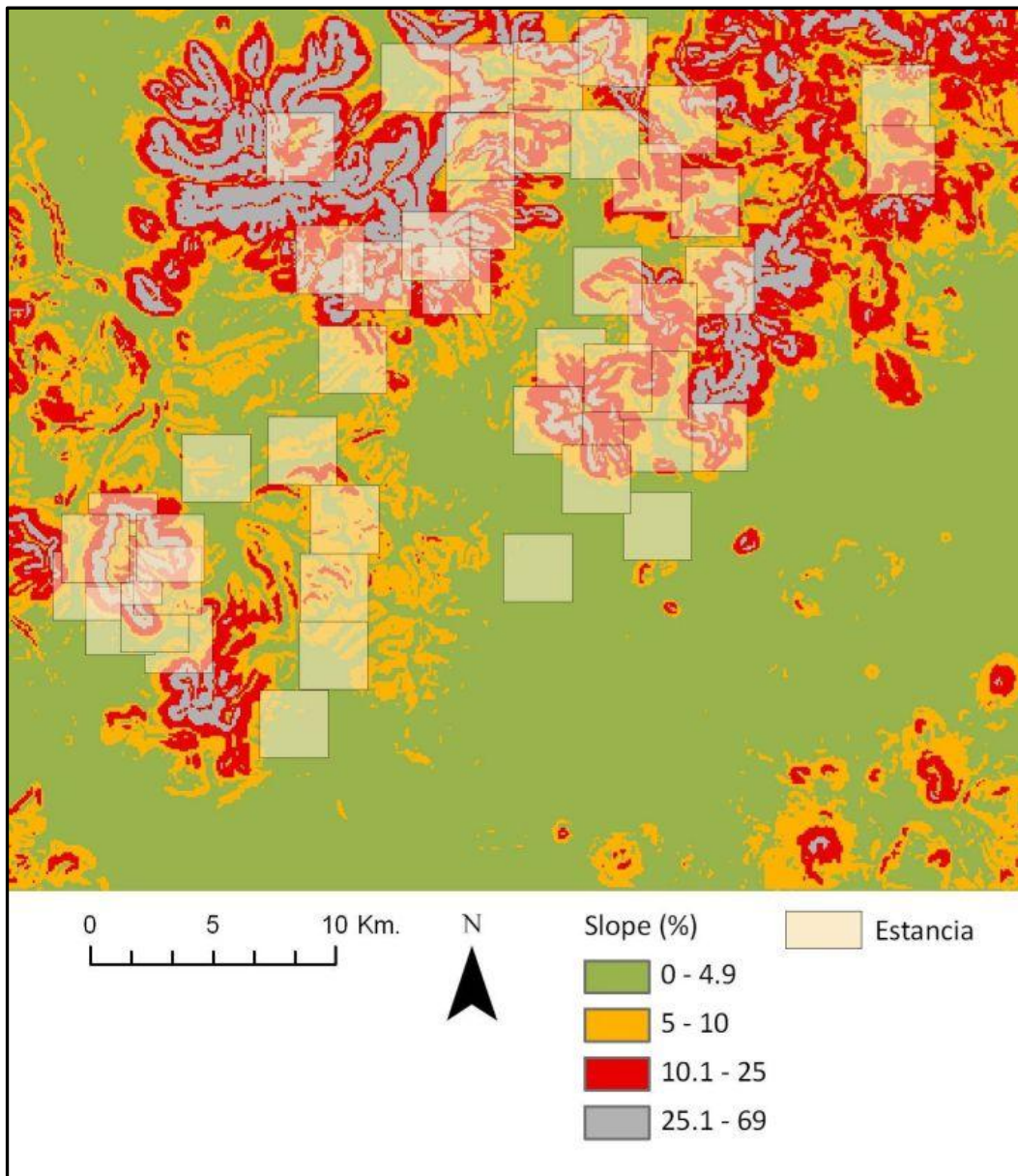
The Rio Salado's course intersects only three estancias (Figure 5.18). Of these three, one is the study area's first known estancia and another is the fifth (of 47 total). This spatio-temporal pattern is in line with Endfield *et al.*'s (2004, 226-7) finding that Guanajuato's earliest estancieros secured access to water supplies. The pattern also appears to underscore the conscious efforts of the Viceroyalty to place estancias away from the more agriculturally productive humid lowlands. Indeed, the U-shaped low-lying Cañada de Tezontlalpa was largely free of estancias. However, after agriculturalists harvested their crops estancieros were legally entitled to bring in their livestock for stubble-grazing (*derrota*

*de mieses*) (*Recopilación 1841*, libro 4 titulo 17 ley 6).<sup>26</sup> Another spatial pattern related to hydrology is that except in the Cañada de Tezontlalpa the estancias overwhelmingly encompassed currently known jagüeyes (Figure 5.21). It is likely that some of these jagüeyes date to the late-colonial or modern periods. However, the pattern still holds that estancieros valued access to surface waters. The cluster of jagüeyes in the eastern edge of the map but without nearby estancias may have a number of explanations. First, it may reflect inaccurate



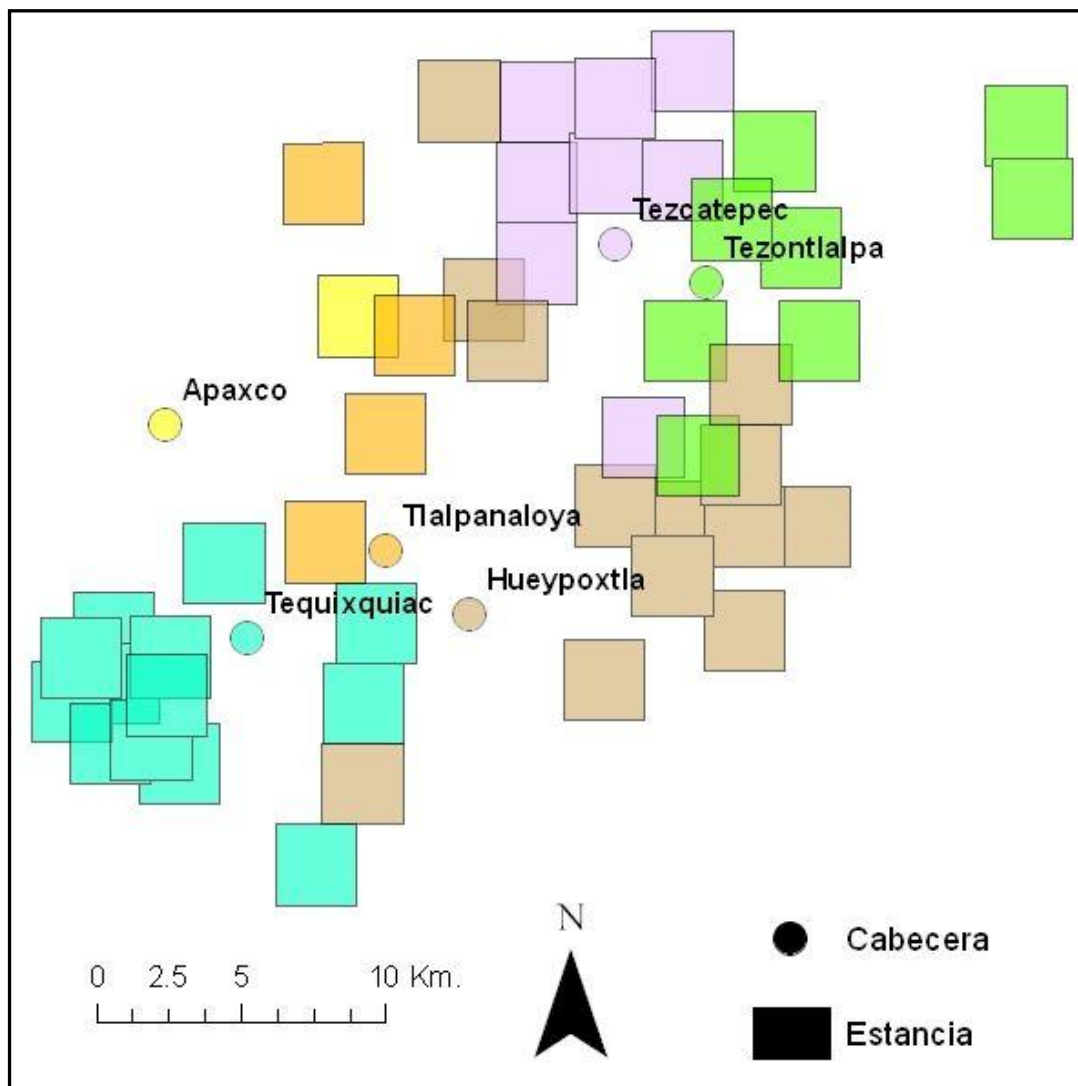
**Figure 5.21.** Jagüeyes and estancias

mapping of estancias. Second, those jagüeyes may post-date the Early Colonial Period. Third, estancias may have been near them but the mercedes for these estancias are no longer preserved. Fourth, these jagüeyes may have been in lands that were under the jurisdiction of either the cabecera Tolcayuca or Guaquilpa because they are closer to those two sixteenth-century cabeceras than they are to any in the study area.



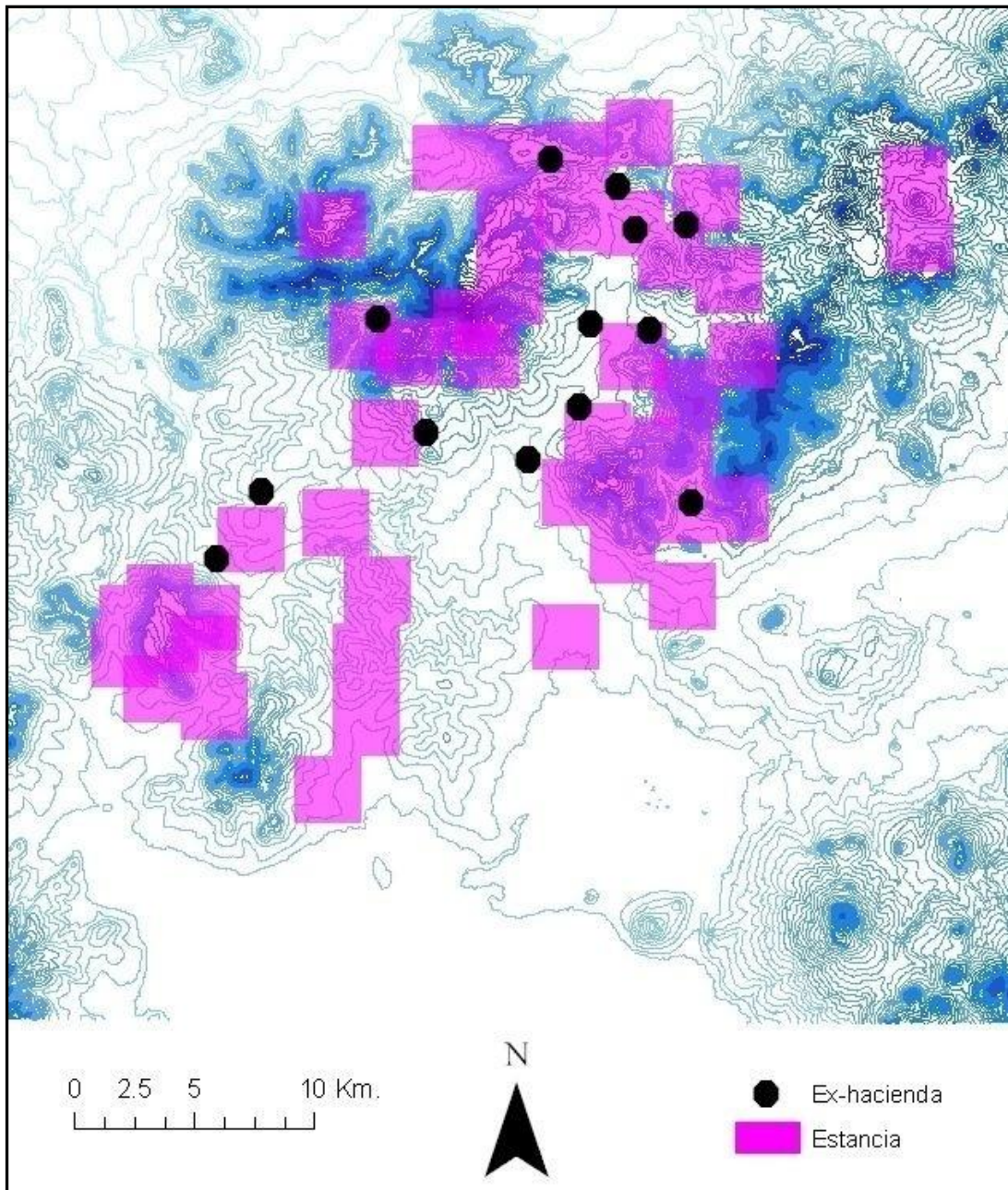
**Figure 5.22.** Estancias and hillslope classes

The metepantli semi-terraces in the study area would have occupied slopes of 5-25 percent, but more common on slopes toward the lower end of that range. Although estancias occupied much of the land with a 10-25 percent slope, land with a 5-10 percent slope remained relatively free of estancias (Figure 5.22). There may have been continuously tended metepantli on those slopes that precluded the land being granted. An unanticipated but interesting result of mapping the study area's estancias is a general depiction of the cabecera's administrative jurisdictions during the Early Colonial Period (Figure 5.23).



**Figure 5.23.** Cabecera jurisdictions. Estancias share the color of the cabecera in whose jurisdiction they were awarded





**Figure 5.24.** Estancias and ex-haciendas

There appears to be a spatial correspondence between estancias and the larger hacienda estates that dominated rural land-use in the later colonial era (Figure 5.24). This strengthens Lockhart's (1969) contention that mercedes formed the legal basis for private land-ownership that enabled haciendas to arise. For example, in the first decade of the

seventeenth century Bernardino de Estrada was not only applying for mercedes, but also purchasing ones that the Viceroy had granted decades earlier.<sup>27</sup> He eventually accumulated the 10 estancias and 20 caballerías that would form his family's hacienda.<sup>28</sup> By the mid-to-late seventeenth century the Jesuits had also acquired tracts of ranchland in the study area (Arellano 1976, n.p.).<sup>29</sup> The study area's hacienda structures tended to occupy humid bottomlands, with their associated rangelands (former estancia lands) extending up hillslopes. This indicates that the haciendas operated under a system of agro-pastoralism that reserved productive lowlands for agriculture and more marginal lands for pastoralism, essentially continuing the early-colonial land-use pattern but within new socio-economic contexts.

## **Conclusion**

This chapter represents an attempt to reconstruct the spatio-temporal patterns of the study area's estancias. I situate this research within the emerging geographical subdiscipline of historical GIS. Estancias can be mapped because each merced includes a description of its location. The quality, length, and overall usefulness of each of these descriptions varies. However, a combination of archival and field work can minimize inherent limitations and increase mapping accuracy.

Quantitative analysis of the spatial characteristics all 47 estancias provides some confirmation that my reconstruction is in line with historical reality. I am here referring to the earliest group of estancias (1535-1544CE) having the lowest average elevations and slopes. I also have in mind the finding that the earliest group of estancias has the highest percentage of land with a southerly aspect and the latest group has the highest percentage of land with a northerly aspect. All of these conclusions about the changing spatial attributes

of estancias make sense, and so they go some way toward validating the accuracy of my mapping.

Other significant spatial patterns emerge from the spatial arrangement of estancias. First, estancias were most heavily grouped and overlapped on prominent elevations that are surrounded by lower lying areas. A somewhat related pattern is that estancias were largely absent along the Rio Salado and within the low-lying Cañada de Tezontlalpa. Both of these patterns can be explained by the conscious effort of the viceroys to keep estancias out of the most productive agricultural lands. Finally, there is a tentative spatial association between the location of haciendas and lands granted as estancias, which suggests that early-colonial land-granting formed the legal and spatial bases for the haciendas.

#### End Notes

1. One is reminded here of how Baker *et al.* (1970, 14) describe historical source material in geographic research: “In most cases the original sources were prepared for such purposes as taxation, valuation or administration and are thus not explicitly geographical. This provides the historical geographer with his [sic] main problem of interpretation – *to build from and into his [sic] source material the necessary spatial dimension*” [emphasis added].
2. Scholars who use mercedes are not alone in their difficulties trying to reconstruct an early-colonial Mexican landscape. In his study of late-sixteenth century native wills from Culhuacan, Mexico Cline (1984, 282) writes, “Despite numerous recurrences of the same toponyms in different testaments and other indications of parcel locations, it is not possible to draw a map of Culhuacan and place the toponyms precisely.”
3. “a las faldas del cerro que dizen de Aranda a la parte del poniente junto a un xaguey viejo como legua y media del dicho pueblo” (AGNM v. 12 f. 57r.).
4. Merced awarded to Diego Mercado: AGNM v. 17 f. 52r.-v.
5. Merced awarded to Gabriel de Fonseca: AGNM v. 12 f. 209r.-v. Documentation of Fonseca selling his merced to Diego Ruiz: AGNT v. 1748 exp. 1 f. 30r-34v.
6. López and Bravo served together under Hernán Cortés during the siege of Tenochtitlán. Bravo testified on López’ behalf in the latter’s attempt at

remuneration for overseeing the construction of the brigantines that were instrumental in the siege (Gardiner 1958, 128).

7. AGNM v. 5 f. 253r.-v.
8. AGNI v. 32 exp. 100r.-102v.
9. AGNT v. 2697 exp. 11 f. 317r.-332v.
10. AGNM v. 9 f. 272v.-273r., v. 9 f. 273r.-v., v. 9 f. 273v.-274v., v. 9 f. 274v.-275r., v. 9 f. 275r.-v.
11. AGNGP v. 1 f. 181r.
12. It is likely that natives abandoned the more agriculturally marginal lands first, and in a macabre way this would have increased overall agricultural efficiency (Ioffe *et al.* 2004).
13. AGNM v. 12 f. 209r.-v.
14. AGNI v. 5 exp. 940 f. 241v.-242r.; AGNIV caja 5920 exp. 43
15. AGNI v. 6 parte 2 exp. 998 f. 260r.-v.
16. The suffix “-ejo” in Medieval Castilian was added to words ending in “l,” such as “pedregal,” in order to create a diminutive form. The “-ejo” suffix did not connote a diminutive *and* pejorative meaning in the sixteenth century as it does today (González Olle 1962, 195).
17. Butzer (1992a, 148) suggests that some references in the Valle del Mezquital’s later mercedes to a poor environment may simply reflect inherently marginal lands rather than degradation. He lists cerros and lomas as examples of marginal lands. In my study area the period 1559-1568 has 13 estancias sited on cerros and lomas and the period 1589-1596 has just six (Table E.1). In the earlier period there are no references to either desiccation or large erosional features despite having over twice as many estancias in cerros and lomas than the later period.
18. AGNI v. 5 exp. 619 f. 171v.-172r.
19. AGNI v. 5 exp. 866 f. 225r.
20. AGNI v. 6 exp. 231 f. 58v.-59r.
21. AGNIV caja 5927 exp. 6.; AGNM v. 23 f. 113r.-v.
22. AGNM v. 18 f. 278v.-279r., v. 19 f. 168r.-v.

23. AGNT v. 1532 exp. 4 f. 46, MAPOTECA #1098).
24. In the mercedes the term “monte” could refer either to vegetative scrub or woodland, or a small mountain or a hill (an English-Spanish dictionary from 1623 carries both these meanings as well [Perceval 1623, 172]). Making this distinction, however, requires the context provided by the entire description, and even then a case could still be made for the other meaning. For example, one merced describes an estancia “en unos montes y laderas [slopes; hillsides] altas,” “los montes de Ajacuba,” and “otros cerros y montes que hacen el medio día” (AGNM v. 15 f. 161r.-v.). Here it seems most reasonable to conclude that “monte” means a hill. Another merced presents, “una cañada grande que esta entre dos cerros grandes en una banda de monte hazia el poniente al pie del monte” (AGNM v. 26, f. 207v.-208v.). The “banda de monte” suggests a band of scrub in a cañada.
25. AGNM v. 24 f. 72v.
26. An ordinance passed in 1576 proclaimed that while crops are growing it is incumbent upon native agriculturalists to either enclose their fields or post a guard to avoid damages from intruding livestock (Ventura Beleña 1981, 110). In Hueyoptla in 1596 native agriculturalists informed the Viceroy that a local estanciero’s sheep were destroying their sementeras. In this case, the Viceroy’s decision echoed earlier ordinances which held that ranchers must keep their sheep out of the sementeras from the beginning of May until the end of November (AGNI v. 6 parte 2 exp. 998 f. 260r.-v.; Ventura Beleña 1981, 46-7). Chevalier (1963, 57) believes that stubble-grazing only became an issue in the later half of the sixteenth-century when much of the unclaimed rangeland had been officially awarded as private property, increasing the importance of stubble as a key resource.
- Bayer and Waters-Bayer’s (1994, 68) overview of herder-farmer relations in semi-arid Africa corresponds to the historical data from New Spain. They find local cycles of conflict-cooperation to be common as livestock occasionally intrude into sewn fields in one part of the year, and graze on stubble and deposit manure in another part of it.
27. AGNM v. 26 f. 161v.-162v.; AGNT 2704 exp. 30 f. 252r.; AGNIV v. 6718 exp. 53 f. 1r.
28. AGNM v. 58 f. 65v.-66v.
29. AGNT 1748 exp. 1 f. 30r.-34v.

## CHAPTER 6: CONCLUSION

### Summary

The previous chapters reflect my ongoing struggle to address this dissertation's central research question: What were the agents and processes of environmental transformation in early-colonial central Mexico? Previous scholars from diverse disciplines have approached this question by drawing upon the techniques of geomorphology, palynology, palaeolimnology, and/or archival sources. Their results have often been inconclusive or contradictory. Even scholars who engage similar data, such as historical geographers and environmental historians, have reached contradictory conclusions. This is why this dissertation has consistently pounded a methodological drumbeat. Conservative assumptions and statements would go a long way toward reconciling different positions on the role of sheep in environmental degradation. For example, different methods of identifying discrete estancias in archival sources has led to different calculations grazing densities and so also contrasting perceptions of livestock as erosional agents (see for example Melville 1983 and Sluyter 1995). I have erred on the side of caution when inferring the existence of estancias from sources outside AGN-Mercedes. Although it is undeniable that a certain number of mercedes are no longer preserved in any source, I have no guide by which to "correct" for these missing estancias. Admittedly, this may lead to an under-appreciation of the role of sheep in causing the region's soil erosion. But it does avoid the reciprocal danger of over-estimating their importance. This over-estimation is the primary fault I find in Melville's (1994) narrative of the Valle del Mezquital's environmental transformation. An ancillary benefit of a conservative methodology is that it keeps the researcher open to novel perceptions of other possible mechanisms of landscape change. For example, while reading the mercedes I developed a heightened perception of

agricultural terrace abandonment as an additional possible mechanism for early-colonial soil erosion. This mechanism would have acted alongside, and in some locations been exacerbated by, the deprivations of livestock herbivory and trampling.

Of all the explanations for central Mexico's environmental degradation, the role of livestock remains the most controversial among scholars. Again, this is why I have followed a conservative methodology when identifying estancias. Such a move also helps to minimize biases that may arise from my own positionality. But also invaluable for assessing the role of livestock besides simply the number of estancias are the spatio-temporal patterns of the land granting process that have emerged from mapping them. In order to tease these patterns out of the archival record I had to define a relatively small study area. This allowed me to scour archival collections for relevant documents and maps, and then read them more closely than I would likely have been able to with a larger study area and more archival data before me. With a small study area it was also possible to thoroughly familiarize myself with the present landscape and relate it to the landscape(s) that archival sources describe. This combination of archival and field work resulted in the identification of 47 estancias, 32 of which can be mapped in a GIS with an estimated precision of +/- 2 km. This dissertation is a contribution to the rapidly emerging field of historical GIS. Within the GIS environment it is possible to calculate the various spatio-temporal characteristics of Mexico's early-colonial ranches including their average slopes, aspects, and elevations. This dissertation is the first study to calculate these characteristics. The accuracy of how I mapped the study area's 47 known estancias is to some extent validated by the relationships between slope, aspect, elevation, the award date, and viceregal intentions. For example, the siting of the earliest estancias in the humid lowlands along the Rio Salado and the later ones clustered on higher elevations fits well with previous scholarship. Another pattern that makes sense is that the

earliest estancias had the highest percentage of their land with a southerly aspect and the lowest average slope and elevation. Likewise, the last estancias to be awarded had the highest percentage of their land with a northerly aspect.

Meaningful spatio-temporal patterns emerge in this dissertation because a smaller study area is conducive to accurate mapping. However, a small study area also inhibits a clear understanding of phenomena that appear only sporadically in the archival record, such as soil erosion, desiccation, and vegetation. For example, the paucity of archival references to vegetation types prevents useful statements being made that connect spatio-temporal changes in vegetation to land-use, aspect, slope, and elevation. But even so, archival documents written before around 1580 contain few or no indications of soil erosion, desiccation, or vegetative species that colonize disturbed areas. This suggests that much of the present land degradation did not occur in the pre-Hispanic era. If this dissertation's findings are to be corroborated for areas with different early-colonial social and biophysical contexts, then its methodology must be repeated in another section of the Valle del Mezquital, or expanded along a regional transect. If future researchers engage in such an endeavor, then I hope that they can exploit the tabular data contained in the appendices in ways I did not imagine.

### **The Process of Environmental Transformation**

I opened this dissertation with William Denevan's (1992, 376) call for a resolution to the debate between Butzer and Melville over the role of sheep in the environmental transformations of colonial Mexico. Contrary to Butzer's findings for the Bajío, I found in my study area increasing environmental desiccation and soil erosion as the sixteenth century progressed to suggest that the Valle del Mezquital's present degraded condition dates from the Early Colonial Period. And contrary to Melville's findings for the entire Valle del



Mezquital, my review of her of methodology and my own archival investigation into the study area's estancias do not support the thesis that sheep over-grazing was the sole significant agent of environmental degradation. Rather, this dissertation supports a process that Denevan himself identified in his 1967 article on the origins of nineteenth-century gullying in New Mexico. Denevan studied the historical records of landscape degradation and sheep pastoralism and concludes:

The 19th century pattern that emerges, then, is one of: 1) higher than average rainfall and high livestock numbers, with little or no arroyo cutting; 2) drought and low livestock numbers, with little or no arroyo cutting; 3) high intensity rainfall, low livestock numbers, and little or no erosion; and 4) drought followed by several years of heavier than average summer storms, high livestock numbers, a probably weakened vegetation cover, and intense arroyo cutting. . . . Actually, all three factors of overgrazing, drought, and high intensity rainfall were to some extent operative and influential in the intensive gullying that took place in the latter part of the nineteenth century (1967, 702).

In the Valle del Mezquital in the final twenty years of the sixteenth century deep drought conditions existed when the sheep population was reaching its peak. This created a latently unstable environment that degraded upon the arrival of drought-breaking rains. But unlike in New Mexico, a contributing process in the Valle del Mezquital's degradation was agricultural terrace abandonment. I have found no archival references to intense summer precipitation following the drought that would correspond to Denevan's sequence of events for New Mexico. But while in the field I conducted an informal interview with Augustín Olivares Hernández, a 96 year-old oral historian who has spent his life in Santa María Ajoloapan, near the former site of Tezcatepec.<sup>1</sup> Archival sources relate that by 1600 Tezcatepec went through a congregación.<sup>2</sup> When I asked Mr. Olivares Hernández why Tezcatepec no long exists, he said that in the early seventeenth century heavy rains washed the settlement away.<sup>3</sup> At the time, I did not realize the significance of his statement. But

now, at the conclusion of my research, it “fits” into a coherent multi-causal narrative of landscape transformation.

Finally, more can be done to understand how drought, introduced sheep, and land abandonment operated synergistically to alter the Valle del Mezquital’s hydrology, soils, and vegetative community. Corroborating lines of evidence, such as could be provided with (geo)archaeology, would be invaluable complements to archival-based studies (Millington and Pye 1994). More can also be done to determine how recent insights into the functioning of non-equilibrium rangelands can be applied to historical landscape studies (see for example Sullivan and Rohde 2002; Janssen *et al.* 2004; Vetter 2005; Gillson and Hoffman 2007).

#### **End Notes**

1. Briggs (1987) compared oral history with the archival documents pertaining to the Pueblo Quemado land grant from the early eighteenth century at Córdoba, New Mexico. Briggs (1987, 239) found, “An initial, striking observation about the oral historical and archival sources on Córdoba is that there are remarkably few discrepancies of fact between the two sources of evidence.”
2. AGNIV caja 5927 exp. 6; AGNM v. 23 f. 113r.-v.
3. Richard Hunter field notebook, 28 July 2006.

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## APPENDIX A: MERCEDES SOURCES

**Table A.1.** Mercedes sources

No.	Date	Cabecera	Grantee	Number and type	Reference
1	1542	Tequixquiac	Martin Lopez	1 estancia para ganado menor 2 caballerías	AGNM v. 2 f. 50v.
2	3/24/1544	Hueyoptla	Anton Bravo de Lagunas	2 estancias para ganado menor 2 caballerías	AGNM v. 2 f. 321r.
3	11/30/1559	Tuzantlalpa	Luis de Villegas	1 estancia para ganado menor	AGNT v. 2704 exp. 30 f. 251r.
4	2/25/1561	Tlapanaloya	Melchior de Chaves	1 estancia para ganado menor	AGNM v. 5 f. 253r.-v.
5	10/2/1562	Tuzantlalpa	Diego Diaz	1 estancia para ganado menor	AGNIV caja 4696 exp. 2
6	10/27/1562	Hueyoptla	Pedro Lopez de Nava	1 estancia para ganado menor	AGNIV caja 4696 exp. 2
7	12/3/1562	Hueyoptla	Maria Frias	1 estancia para ganado menor	AGNIV caja 4696 exp. 2
8	12/3/1562	Tezcatepec	Luis de Villegas	1 estancia para ganado menor	AGNIV caja 4696 exp. 2
9	4/30/1563	Apaxco	Juan Garcia	1 ½ caballerías	AGNM v. 6 f. 204v.-205r.
10	4/30/1563	Tuzantlalpa	Andres de Estrada	1 estancia para ganado menor	AGNM v. 6 f. 205r.
11	3/1/1564	Tuzantlalpa	Christoval de Aguirre	1 estancia para ganado menor	AGNM v. 7 f. 361r.-v.

12	3/2/1564	Tuzantlalpa	Alonso Vasquez de Molina	1 estancia para ganado menor	AGNM v. 7 f. 361v.-362r.
13	8/7/1565	Tlapanaloya	Melchior de Chaves	2 caballerías	AGNM v. 8 f. 89r.
14	1565	Tlapanaloya	Diego de Ayo	2 caballerías	AGNM v. 8 f. 101v.
15	4/3/1566	Tezcatepec	Fernando Lopez de Halba	1 calera	AGNT v. 2704 exp. 30 f. 254v-255r.
16	12/1/1566	Apaxco	Luis Gomez	1 calera	AGNM v. 8 f. 227v.-228r.
17	1/26/1568	Tequixquiac	Pedro de San Juan	1 estancia para ganado menor	AGNM v. 9 f. 272v.-273r.
18	1/26/1568	Tequixquiac	Pedro de San Juan	1 estancia para ganado menor	AGNM v. 9 f. 273r.-v.
19	1/26/1568	Tequixquiac	Antonio Cortes	1 estancia para ganado menor	AGNM v. 9 f. 273v.-274v.
20	1/26/1568	Tequixquiac	Juan Bautista	1 estancia para ganado menor	AGNM v. 9 f. 274v.-275r.
21	1/26/1568	Tequixquiac	Community of Tequixquiac	1 estancia para ganado menor	AGNM v. 9 f. 275r.-v.
22	1/29/1568	Tequixquiac	Martin Lopes	2 caballerías	AGNM v. 9 f. 279r.-280r.
23	5/2/1568	Hueypoxtla	Francisco Muñoz	2 caballerías	AGNIV caja 4696 exp. 2
24	10/2/1568	Hueypoxtla	Esteban Diaz del Valderrama	1 estancia para ganado menor	AGNT v. 2704 exp. 30 f. 253v.-254r.
25	9/3/1575	Tlapanaloya	Melchior Davila	1 calera	AGNM v. 10 f. 76r.-77v.
26	2/4/1577	Tequixquiac	Gabriel de Soto	1 estancia para ganado menor	AGNM v. 10 f. 198v.
27	1580	Tlapanaloya	Anton Bravo	1 calera	AGNT v. 2697 exp. 10 f. 306r.-316v.

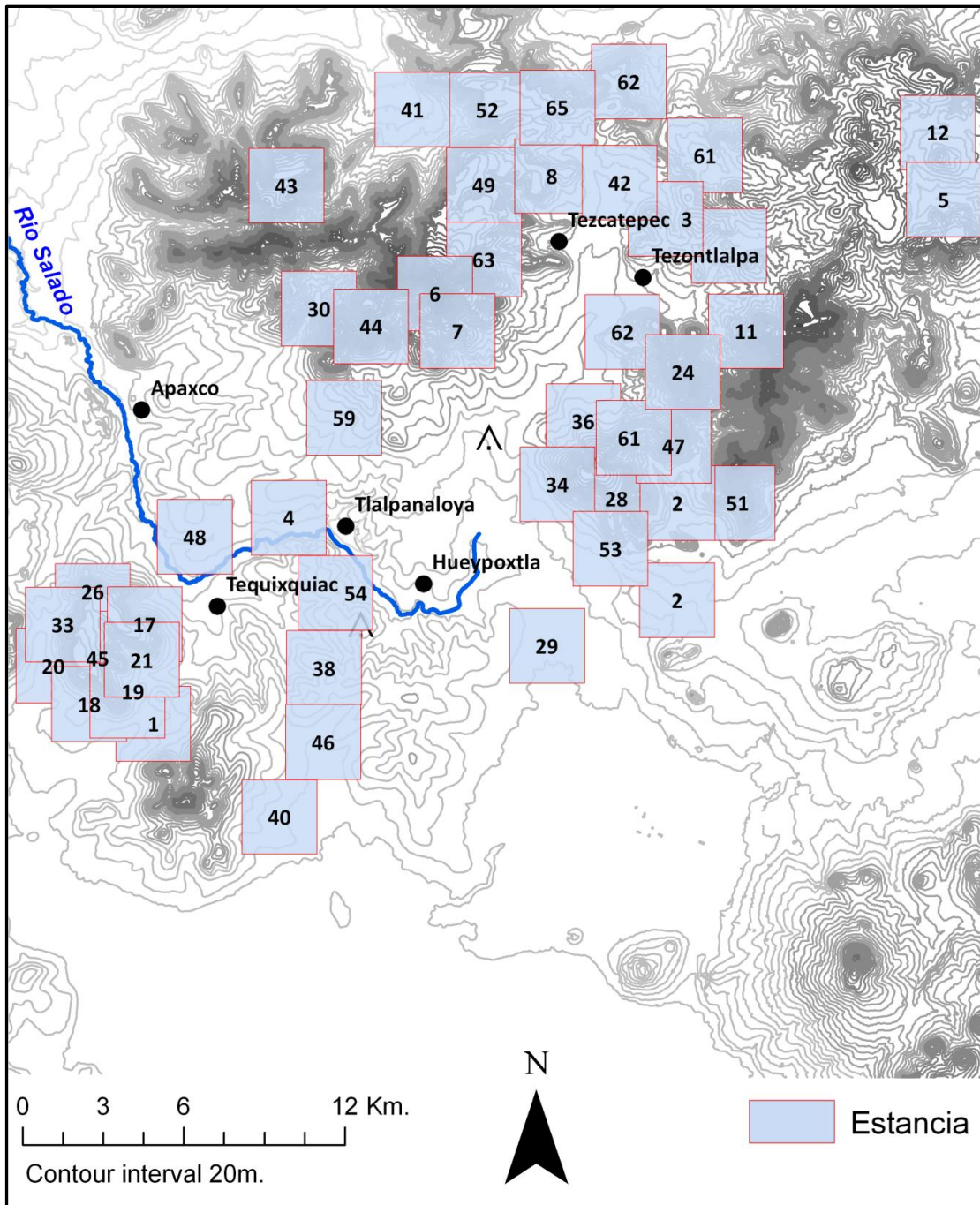


28	9/27/1580	Hueyoptla	Alonso de Mansilla	1 estancia para ganado menor	AGNT v. 2704 exp. 30 f. 252r.
29	12/8/1582	Hueyoptla	Estancio Carvajal	1 estancia para ganado menor	AGNIV caja 5764 exp. 113
30	3/2/1583	Apaxco	Beatriz de Rivera	1 estancia para ganado menor 1 calera	AGNM v. 13 f. 41r.-v.
31	7/27/1583	Tequixquiac	Francisco Garcia	1 caballería	AGNM v. 12 f. 37v.-38r.
32	10/26/1583	Hueyoptla	Alonso de Mansilla	4 caballerías	AGNM v. 12 f. 9v-10r.
33	2/4/1584	Tequixquiac	Lorenzo Luna	1 estancia para ganado menor 2 caballerías	AGNM v. 12 f. 56v.
34	2/4/1584	Hueyoptla	Luis Bohorquez	1 estancia para ganado menor 2 caballerías	AGNM v. 12 f. 57r.
35	5/19/1584	Apaxco	Luis Mata	1 caballería	AGNM v. 12 f. 84v.
36	7/19/1585	Tezcatepec	Lucia Rrengina	1 estancia para ganado menor 2 caballerías	AGNM v. 12 f. 133v.-134v.
37	9/11/1585	Tequixquiac	Luis Mata	1 ½ caballerías	AGNM v. 12 f. 153r.
38	8/18/1586	Tequixquiac	Gabriel Fonseca de Castellanos	1 estancia para ganado menor 2 caballerías	AGNM v. 12 f. 209r.-v.
39	11/26/1586	Tequixquiac	Lorenzo Luna	3 caballerías	AGNM v. 13 f. 244v.-245r.
40	6/2/1589	Tequixquiac	Francisco Hernandez de Rivera	1 estancia para ganado menor	AGNM v. 14 f. 232r.-v.

41	6/2/1589	Hueyoptla	Alonso Ximenez de Portilla	1 estancia para ganado menor	AGNM v. 14 f. 232v.-233v.
42	12/9/1589	Tezcatepec	Diego Gonzales	1 estancia para ganado menor	AGNM v. 14 f. 417r.-v.
43	3/26/1590	Tlapanaloya	Maria de Gusman	1 estancia para ganado menor	AGNM v. 15 f. 161r.-v.
44	3/26/1590	Tlapanaloya	Alonso de Galdo Gusman	1 estancia para ganado menor	AGNM v. 15 f. 161v.-162r.
45	8/9/1591	Tequixquiac	Diego Mercado	1 estancia para ganado menor 4 caballerías	AGNM v. 17 f. 52r.-v.
46	11/29/1593	Hueyoptla	Community of Hueyoptla	1 estancia para ganado menor 2 caballerías	AGNM v. 18 f. 278v.-279r.
47	11/29/1593	Hueyoptla	Community of Hueyoptla	1 estancia para ganado menor 2 caballerías	AGNM v. 19 f. 168r.-v.
48	6/16/1595 [~1535]	Tequixquiac	Beatriz de Rivera [Martin Lopez]	1 estancia para ganado menor	AGNM v. 21 f. 80v.-81r.
49	11/19/1596	Tezcatepec	Luis de Soto Cabezon	1 estancia para ganado menor 2 caballerías	AGNM v. 22 f. 76r.-v.
50	5/13/1597	Hueyoptla	Domingo Hernandez	2 caballerías	AGNM v. 22 f. 128v.-129r.
51	6/5/1600	Hueyoptla	Diego Lopes de las Rroble	1 estancia para ganado menor 2 caballerías	AGNM v. 23 f. 87v.-88r.
52	10/20/1600	Tezcatepec	Gregorio de Soto	1 estancia para ganado menor	AGNM v. 23 f. 113r.-v.

53	11/28/1600	Hueypoxtla	Felipe de las Rrobles Quiñones	1 estancia para ganado menor 2 caballerías	AGNM v. 24 f. 28v.-29r.
54	4/24/1603	Tequixquiac	Maria Ordoñez	1 estancia para ganado menor 2 caballerías	AGNM v. 24 f. 141r.-v.
55	4/24/1603	Tequixquiac	Juan Bautista de Ureta	3 caballerías	AGNM v. 24 f. 141v.-142r.
56	4/24/1603	Tequixquiac	Juan Bautista de Ureta	5 caballerías	AGNM v. 24 v. 142r.-v.
57	3/26/1604	Apaxco	Juan de Figueroa	1 calera	AGNM v. 24 f. 177v.-178r.
58	8/18/1605	Tezcatepec	Luis de Soto Cabezon	4 caballerías	AGNIV caja 4696 exp. 2
59	10/17/1606	Tlapanaloya	Sancho Barahona	1 estancia para ganado menor 4 caballerías 1 calera	AGNM v. 25 f. 132r.-133r.
60	3/12/1607	Hueypoxtla	Melchior de Soto	2 caballerías	AGNT v. 2704 exp. 30 f. 254v.
61	4/3/1609	Tuzantlalpa	Bernardino de Estrada	2 estancias para ganado menor 4 caballerías	AGNM v. 26 f. 161v.-162v.
62	8/20/1609	Tezcatepec	Luis de Soto Cabezon	2 estancias para ganado menor 4 caballerías	AGNM v. 26 f. 207v.-208v.
63	8/25/1609	Tezcatepec	Luis de Soto Cabezon	1 estancia para ganado menor	AGNM v. 26 f. 208v.-209v.
64	8/29/1609	Hueypoxtla	Jacobo de Arragon	3 caballerías 1 calera	AGNM v. 26 f. 213v.-214v.

65	2/8/1610	Tezcatepec	Gregorio de Soto	1 estancia para ganado menor	AGNIV caja 4696 exp. 2
66	2/16/1610	Hueyoptla	Luis de Soto Cabezon	2 caballerías	AGNIV caja 4696 exp. 2
67	10/6/1625	Hueyoptla	Jacobo de Arragon	3 caballerías 1 calera	AGNT v. 1634 exp. 4 f. 315r.-316v.



**Figure A.1.** The spatiality of estancias referenced in Table A.1

## APPENDIX B: ESTANCIA LOCATION ANALYSIS

Different levels of detail among the mercedes has resulted in some estancias being more accurately mapped than others. I have classified the estancias into two groups based upon mapping accuracy. The first group has sufficient physiographic, toponymic, cartographic, or other detail to map their centroids to within 2 km. The second group lacks such detail and their centroids I have mapped with less confidence. The rationale behind the placement of each estancia follows.

I retain original spellings, punctuations, and capitalizations in order to preserve the accuracy and intended meaning of the original records (Villasana Haggard 1941, 110-1). In brackets I provide the English translation of some Spanish landscape terms and obscure phrases. I have also placed in brackets letters missing from the original documents but may be useful for word comprehension. An “x” represents each letter that I am unable to transcribe from the original document because of damaged paper, faded ink, or illegible script.

**Appendix A reference number** - cabecera/date/grantee/reference to merced (accuracy)

**1** - Tequixquiac/1542/Martin Lopez/AGNM v. 2 f. 50v. (>2 km)

AGNM v. 2 f. 50v: “El sitio de estancia en una cañada que se dize guiguexxx en una xxxxx que esta en xx un coral? de magueyes.” Presumably this cañada is between two substantial elevations and not just lomas, but I cannot be certain of that and that is why this estancia’s location is in doubt. I have mapped this estancia at a pass between two high elevations to the south-southwest of the town.

**2** - Hueypoxtla/1544/Anton Bravo de Lagunas/AGNM v. 2 f. 321r. (+/-2 km)

AGNM v. 2 f. 321r.: “[h]aga mrd. de dos caballerias de tierra y dos sitios de estancias en los terminos de los pueblos de gueipustlan y tolcaucan. el un sitio [en una] canada a dentro de Sacacalco entre los dos terminos frontero de [facing] un pueblo despoblado que se dice San Felipe ig. [Ignacio] hago junto a unos jagueies, el otro corre desde una parte de S. Francisco Vertientes de la Canada de Sacacalco en unos llanos entre los dos terminos de los dichos

pueblos y las caballerías en medio de los dichos sitios de estancias junto al dicho pueblo de S. Francisco a la orilla del [next to] camino real que ba a tolcaucan.” All of the toponyms this merced cites are known. The first estancia is in the cañada that is north of Zacacalco, where there is the ex-Hacienda La Cañada and a jagüey named San Ignacio (INEGI 1:50,000 topographic map E14B11, 1998). The second estancia is said to be amidst plains. It seems to have been situated in the flatlands immediately south of Zacacalco because the accompanying caballerías are said to be between the two estancias next to Zacacalco – one estancia was to the north of the pueblo and the other to the south with the caballerías and the pueblo between them.

**3 - Tuzantlalpa/1559/Luis de Villegas/AGNT v. 2704 exp. 30 f. 251r. (>2 km)**

AGNT v. 2704 exp. 30 f. 251r.: “un sitio de Estancia para ganado menor en terminos del pueblo de Tuzantlalpa donde dicen xxxx en tierras baldias.” Despite having no referent for this estancia because of its relatively early date I have mapped it near the cabecera with the assumption it would have occupied better lands.

**4 - Tlapanaloya/1561/Melchior de Chaves/AGNM v. 5 f. 253r.-v. (+/-2 km)**

AGNM v. 5 f. 253r.-v.: “un sitio de estancia para ganado menor en terminos del pueblo de Talpanaloya en un llano junto a un arroyo de agua que va poniente del norte.” The “arroyo de agua” probably refers to the Salado de Hueyoptla, which flows northwest towards Apaxco.

Four years later in 1565 Melchior de Chaves received two caballerías in a loma that borders the land of Tequixquiac, giving further indications that he was acquiring land in the interstice between Tlapanaloya and Tequixquiac (AGNM v. 8 f. 89r.)

In 1567 he acquired a sitio para venta located along the road to the Mines of Zacatecas that was located 300 pasos from his estancia (AGNM v. 9 f. 152r.-v.). I do not know whether this road went west as the current road does or northwest in a more direct route, but the estancia’s location as I have mapped it is congruent with both scenarios.

**5 - Tuzantlalpa/1562/Diego Diaz/AGNIV caja 4696 exp. 2 (+/-2 km)**

AGNIV caja 4696 exp. 2: “Dicho sitio esta en terminos del Tuzantlalpa y Hueytepeque junto a un pedregal [stony ground] en una loma encima de una cenda que va a Pachuca.” Halfway between between Tezontlalpa and Pachuca is the small pueblo Huitepec (INEGI 1:50,000 topographic map F14D81, 1999). I have mapped this estancia on the loma south of Huitepec that probably overlooked the path that connected Tezontlalpa and Pachuca.

**6 -Hueyoptla/1562/Pedro Lopez de Nava/AGNIV caja 4696 exp. 2 (+/-2 km)**

AGNIV caja 4696, exp. 2: “Esta en terminos del pueblo de Gueypustla entre dos canadas al pie de un cerro que llama Tianguistongo.” Tianguistongo was a sujeto of Hueyoptla and its location does not appear to have changed since pre-Hispanic times (Paso y Troncoso 1905, v.

5, 27; v.; Paso y Troncoso 1905, v. 3, 48). The pueblo only has cerros on its western side, so I have centered this estancia on the most prominent cerro that overlooks the pueblo.

**7 - Hueyoptla/1562/Maria Frias/AGNIV caja 4696 exp. 2 (>2 km)**

AGNIV caja 4696 exp. 2: “Esta este [sic] sitio en terminos del pueblo de Tianguistongo cerca del monte [next to the mountain].” Tianguistongo was in the sixteenth century, and still is today, a relatively small settlement whose location does not appear to have changed since pre-Hispanic times (Paso y Troncoso 1905, v. 5, 27; v.; Paso y Troncoso 1905, v. 3, 48). The nearest mountains are the ones that flank the pueblo immediately to the west. I have mapped this estancia on the foothills between the pueblo and mountains.

**8 - Tezcatepec/1562/Luis de Villegas/AGNIV caja 4696 exp. 2 (>2 km)**

AGNIV caja 4696 exp. 2: “en terminos del pueblo de Tezcatepeque encima de un cerro que se dice Apastepeque junto a una cienega [marsh; swamp].” This is the only reference I have found to Apastepeque, which makes the siting of this estancia problematic. The toponym Apastepeque appears to mean “inundated occupied land” (*Apachoa*, to inundate something [Karttunen 1992, 11]; *tepec*, an inhabited place [Peñafiel 1885, 33]). This is supported by the mention of a nearby marsh or swamp. Apastepeque, then, might be a bowl-shaped cerro north of Tezcatepeque and near a mesa that is today known as Mesa La Laguna (INEGI 1:50,000 topographic map F14C89, 2000). However, this is too much conjecture to believe that placing the estancia at this location achieves an accuracy <2 km.

**10 - Tuzantlalpa/1563/Andres de Estrada/AGNM v. 6. f. 205r. (>2 km)**

AGNM v. 6. f. 205r.: “un sitio de estancia para ganado menor en terminos del pueblo de Tezontlalpa, sujeto de Tezcatepeque media legua del dicho pueblo en un palmar a la halda de un cerro que se llama Eustapala.” This cerro is unidentified, so I have situated the estancia one-half league west of Tuzantlalpa, where it can rest upon four cerros. The cerro in question might be one that lies to the north of the town or one to the southeast, but I placed it to the west by considering probability.

**11 - Tuzantlalpa/1564/Christoval de Aguirre/AGNM v. 7 f. 361r.-v. (>2 km)**

AGNM v. 7 f. 361r.-v.: “un sitio de estancia de ganado menor en terminos del pueblo de Tuzantlalpa en una loma que hace un cerro que se llama Tlaltepeque cerca de una tuna[?] grande.” This cerro’s toponym is unknown to me so all that I am usefully left with as a referent is a loma that abuts a cerro in the general environs of the pueblo. To the southeast of the pueblo is a loma that eventually rises to form a few cerros. It is here that I have mapped the estancia.



**12 - Tuzantlalpa/1564/Alonso Vasquez de Molina/AGNM v. 7 f. 361v.-362r. (+/-2 km)**

AGNM v. 7 f. 361v.-362r.: “un sitio de estancia para ganado menor en terminos de Tulcayuca y Tuzantlalpa en la falda de un cerro alto pelado [barren] que llaman Hiutepeque junto a una quebrada que dizen Calpulalpa.” This estancia’s location can be ascertained by the convergence of some toponymic data. First and most useful, Huitepec is a current settlement on the hillside of a cerro halfway between Pachuca and Tezontalpa and 11 km NE of Tezontlalpa and 11 km NNE of Tolcayuca. Second, there is another settlement and stream both called Capula at the far end of the quebrada to the northwest of Huitepec (INEGI 1:50,000 topographic map F14D81, 1999). Lastly, this is the only merced I have for my study area whose inspector is from Pachuca, which indicates that this estancia is relatively near that city in relation to the other estancias. This estancia is adjacent to another estancia that the Viceroy granted two years earlier to Diego Diaz (AGNMIV caja 4696 exp. 2).

**17 - Tequixquiac/1568/Pedro de San Juan/AGNM v. 9 f. 272v.-273r. (+/-2 km)**

AGNM v. 9 f. 272v.-273r.: “un sitio de estancia para ganado menor en terminos del dicho pueblo en un cerro grande junto a un peñasco [pinnacle of rock; crag], que el dicho cerro se llama Mequexcacan, junto a unos tunales silvestres y frontero de la yglesia del dicho pueblo.” The cerro mentioned must be the large one immediately westward of Tequixquiac, which is the only cerro near the pueblo. All of the cerro’s peñascos are on its eastern side and I have placed the estancia on this side directly west of the church.

**18 - Tequixquiac/1568/Pedro de San Juan/AGNM v. 9 f. 273r.-v. (>2 km)**

AGNM v. 9 f. 273r.-v.: “un sitio de estancia para ganado menor en terminos del dicho pueblo en un cerro pedregoso que se llama Tlalcahuyacan.” The only cerro within Tequixquiac’s jurisdiction is immediately west of the pueblo. Each extension, or arm, of this mesa was considered an individual “cerro” and given its own proper name, a practice that continues up to the present. I have placed this estancia on one of those extensions for which no accurately-placed estancia has already been mapped.

**19 - Tequixquiac/1568/Antonio Cortes/AGNM v. 9 f. 273v.-274v. (>2 km)**

AGNM v. 9 f. 273v.-274v.: “un sitio de estancia para ganado menor en terminos del dicho pueblo en un cerro que esta entre dos quebradas que se llama Tepexumylea frontero de unos cerecedas [cherry orchards].” The mesa immediately west of Tequixquiac is probably where this estancia was sited. The toponym hints at its precise location on this mesa (*Tepehxihuia*, to fling oneself headlong; to throw something down from height, or down a ravine [Karttunen 1992, 229]). This corresponds to the merced that describes the cerro being flanked by two ravines (*Melahuac*, something straight, true, or vertical [Karttunen 1992, 143]). Therefore, I have mapped this estancia on the most vertical portion of the mesa that is flanked by ravines.

**20 -Tequixquiac/1568/Juan Bautista/AGNM v. 9 f. 274v.-275r. (+/-2 km)**

AGNM v. 9 f. 274v.-275r.: “un sitio de estancia para ganado menor en terminos del dicho pueblo en un cerro xunta a un sauce [willow] y a un jaguey chico en la falda del dicho cerro que se nombra Tlaxalan.” The only cerro within the granting jurisdiction of Tequixquiac is Mesa Grande, the prominent mesa immediately west of the town. An estancia awarded in 1584 near Tequixquiac describes a “cerro grande” named “Tlatzalan,” which further indicates that Mesa Grande is the correct location for this estancia.

**21 - Tequixquiac/1568/Community of Tequixquiac/AGNM v. 9 f. 275r.-v. (>2 km)**

AGNM v. 9 f. 275r.-v.: “un sitio de estancia para ganado menor en terminos del dicho pueblo en la falda de un cerro que se llama Tezeuetl junto a unos mogotes de piedra a uista [oeste] del dicho pueblo.” This toponym remains unidentified but it must form part of Mesa Grande westward of Tequixquiac. I have placed this estancia adjacent to an estancia that a native of the cabecera received the in same year.

**24 - Hueypoxtlá/1568/Esteban Diaz del Valderrama/AGNT v. 2704 exp. 30 f. 253v.-254r. (>2 km)**

AGNT v. 2704 exp. 30 f. 253v.-254r.: “un sitio de estancia para ganado menor en terminos de los pueblos de Hueypoxtlá y una legua de Tuzantlalpa y Auluapa [Ajoloapan] en el dicho cerro que se dice Sinttecatly? en lo alto y esta? al medio dia junto a unas tunas y piedras.” This tierras record for this estancia states that it was acquired by Bernardino de Estrada, a Spaniard who acquired many estancias NW of Hueypoxtlá around Cerro de Aranda. I have mapped this estancia as the merced states about a league from Ajoloapan and Tezontlalpa, and to the west-southwest so that this estancia is partially beside another estancia that Bernardino de Estrada owned.

**26 - Tequixquiac/1577/Gabriel de Soto/AGNM v. 10 f. 198v. (+/-2 km)**

AGNM v. 10 f. 198v.: “un sitio de estancia para ganado menor en terminos del pueblo de Tequixquiac en un cerro grande que se nombra Maquechuacan junto a un pedrisco [multitude of loose stones].” This cerro’s name appears in a merced for an estancia 11 years earlier (AGNM v. 9 f. 272v.-273r.). That earlier estancia was placed with reasonable accuracy because of its useful description, so this one I mapped on the same cerro.

**28 - Hueypoxtlá/1580/Alonso de Mansilla/AGNT v. 2704 exp. 30 f. 252r. (+/-2 km)**

AGNT v. 2704 exp. 30 f. 252r.: “un sitio de estancia para ganado menor en terminos del pueblo de Hueypustla junto a un serro grande donde parte terminos los pueblos de Tolcayuca y Tuzantlalpa al parte que llaman Quescomactepec.” The only cerro in the environs of Hueypoxtlá is Cerro de Aranda between Hueypoxtlá and Tolcayuca, so this estancia’s location is suspected to be next to this cerro. This merced’s text has been copied

into a composición document that dates from 1712. The document reports that Bernardino de Estrada bought the merced 1608. The following year in 1609 Bernardino de Estrada received a merced (AGNM v. 26 f. 161v.-162v.) for an estancia that I was able to accurately map because of a known toponym (La Cañada). That 1609 merced mentions an estancia he has on the summit of Cerro de Aranda and estancias that border it to both the east and west. Thus, this estancia is situated on top of Cerro de Aranda and forms the western border of the estancia Bernardino de Estrada received in 1609.

**29 - Hueypoxtla/1582/Estancia Carvajal/AGNIV caja 5764 exp. 113. (+/-2 km)**

AGNIV. caja 5764 exp. 113.: “un citio de estancia de ganado menor que es en los terminos de este dicho pueblo en una llanada grande que los naturales llaman Gueytlalpa . . . el pueblo mas sercano a esta estancia que se pide es el de Jilotzingo y estara dell mas de tres quartos de legua y que de este dicho pueblo de Gueypustla estara mas de una legua.” The “llanada grande” must be the N-S plain that runs along the eastern flanks of both Hueypoxtla and Jilotzingo. I have mapped this estancia on that plain in a location that corresponds to the description of  $\frac{3}{4}$  league from Jilotzingo and somewhat more than a league from Hueypoxtla.

**30 - Apaxco/1583/Beatriz de Rivera/AGNM v. 13 f. 41r.-v. (+/-2 km)**

AGNM v. 13 f. 41r.-v.: “un sitio de estancia para ganado menor en un cerro que por nombre Copaltepeque entre otros cerros.” A merced for a calera issued in 1604 relates that the calera is “al pie de un cerro que llaman Copaltepeque en tierras de una estancia de ganado menor de Gonzalo Fernandes de Figueroa, que el dicho sitio de calera esta en una rinconada que hace en el dicho cerro junto a un arroyo seco sobre mano derecha” (AGNM v. 24 f. 177v.-178r.). The locational information from both of these mercedes indicates that the cerro’s location is adjacent to a rinconada, amongst other cerros, and has within it a lime kiln with a stream to the right of the kiln. Through field investigation I located a calera near Apaxco in a rinconada with a stream on its right at the foot of a cerro that is surrounded by other cerros. The convergence of these features likely indicates the location of this estancia. It then appears that this estancia granted to Beatriz de Rivera in 1583 had by 1604 become the possession of Gonzalo Fernandes de Figueroa, for whom I have no record of being awarded a merced for an estancia.

**33 - Tequixquiac/1584/Lorenzo Luna/AGNM v. 12 f. 56v. (+/-2 km)**

AGNM v. 12 f. 56v.: “un sitio de estancia para ganado menor y dentro del dos caballerías de tierra en terminos del dicho pueblo en un cerro grande que nombran Tlatzalan. A la parte del poniente linde con tierras de Gabriel de Castellanos.” This “cerro grande” must be the prominent mesa to the west of Tequixquiac. The neighbor’s “tierras” [likely caballerías] westward of the estancia indicate that that the estancia was located on the western half of the cerro with its western border abutting humid bottomlands. The lower western portion is also where presumably the caballerías were located inside this tract.

**34 - Hueypoxtla/1584/Luis Bohorquez/AGNM v. 12 f. 57r. (+/-2 km)**

AGNM v. 12 f. 57r.: “el dicho sitio a las faldas del cerro que dizen de Aranda a la parte del poniente junto a un xaguey viejo como legua y media del dicho pueblo.” The toponym Cerro de Aranda is current for a prominent cerro near Hueypoxtla.

**36 - Tezcatepec/1585/Lucia Rrengina/AGNM v. 12 f. 133v.-134v. (+/-2 km)**

AGNM v. 12 f. 133v.-134v.; – “el sitio en un serro junto a un palmar serca de la estancia de San Miguel sujeta del dicho pueblo.” The ex-Hacienda San Miguel is in the southern reaches of the lands that were administered by Tezcatepec, so the estancia is presumably no more southerly than this location. The nearest cerro is to the west of San Miguel, which is where a nearby palmar is depicted on an eighteenth-century map (AGNT v. 3256 exp. 1 f. 33, MAPOTECA map #2334).

**38 - Tequixquiac/1586/Gabriel Fonseca de Castellanos/AGNM v. 12 f. 209r.-v. (+/-2 km)**

AGNM v. 12 f. 209r.-v.: “el sitio en una loma alta pedregosa a la mano derecha de un monton de piedra que parece cue antiguo y de una cruz que esta en una senda [path] que va del dicho pueblo a el de Citlaltepec.” A map was drafted in 1591 five years after the merced was awarded that shows exactly where the estancia was located (AGNT v. 2621 exp. 11 f. 9r. MAPOTECA map #1684). Its textual element relates that “aqui esta una estancia despoblada y dos caballerías de tierra que compro Diego Ruiz de Gabriel Castellanos.” The location is shown on the east side of a N-S road that skirts San Miguel to the east; this road still exists and allows for a very accurate placement of the estancia on the loma. This grant was sold within five years of being awarded, and had at least three different owners during the subsequent 30 years (AGNT v. 1748 exp. 1 f. 30r.-34v.).

**40 - Tequixquiac/1589/Francisco Hernandez de Rivera/AGNM v. 14 f. 232r.-v. (+/-2 km)**

AGNM v. 14 f. 232r.-v.: “un sitio de estancia para ganado menor en terminos de Tequisquiaque en unas lomas no muy altas que miran [h]azia el pueblo de Zumpango.” Zumpango is south of Tequixquiac so the estancia is likely on a loma between the two towns. The low loma is described as looking towards Zumpango, indicating that it runs with its length E-W. Two nearby lomas match this description; one is south of San Miguel and the other is farther away from Tequixquiac, south-southwest of Jilotzingo. This second loma is much closer to Jilotzingo than Tequixquiac and because Jilotzingo was a cabecera town an estancia awarded on this loma would probably have been issued from the alcalde mayor of Jilotzingo rather than Tequixquiac. Thus, I have placed this estancia on the loma that is south of San Miguel, closer to Tequixquiac.

**41 - Hueypoxtla/1589/Alonso Ximenez de Portilla/AGNM v. 14 f. 232v.-233v. (>2 km)**

AGNM v. 14 f. 232v.-233v.: “un sitio de estancia para ganado menor en terminos del pueblo de Tlamaco y de Santa Monica sujeto al de gueypustla y al de axacuba en las [f]aldas de un cerro al norte donde junto a un pedregalejo [a stony place] hazia un llano donde [h]ay unos tunales silvestres que distara del [f]alda del dicho cerro [h]asta el dicho pueblo de Santa Monica apartado del como una legua y corre del este a sudeste y de norte a sur, de travesia [of the distance between the two points] y estan otros dos cerros que a la [f]alda de ellos cae el dicho sitio.” The locations of the pueblos Santa Monica and Tlamaco remain unknown. The placement of this estancia is based upon the assumption that the pueblo is between Hueypoxtla and Axacuba on hillslopes above a north-south plain.

**42 - Tezcatepec/1589/Diego Gonzales/AGNM v. 14 f. 417r.-v. (>2 km)**

AGNM v. 14 f. 417r.-v.: “un sitio de estancia para ganado menor en terminos del dicho pueblo en un llano a la falda de un cerro, aguas vertientes hacia el levante que dicho sitio se nombra Tepexomolco, junto a una quebrada que de[s]ciende del [descends from] dicho cerro Tepejomolco.” The toponym Tepejomolco is unknown to me. There is a llano that runs N-S between Tezcatepec and Tuzantlalpa. I have placed this estancia in the northern part of this llano away from Tuzantlalpa because were it closer to that pueblo the merced probably would have cited that pueblo in addition to or instead of Tezcatepec.

**43 - Tlapanaloya/1590/Maria de Gusman/AGNM v. 15 f. 161r.-v. (+/-2 km)**

AGNM v. 15 f. 161r.-v.: “un sitio de estancia para ganado menor en terminos del pueblo de Tlapanaloya en unos montes y laderas [slopes; hillsides] altas que estan hacia la banda del norte en una mesa grande y llana que tiene por linde de la una parte los montes de Ajacuba y por otra estancia de Pedro y Alonso de Gusman y por otra parte estan otros cerros y montes que corren hacia el medio dia [south].” The toponym Ajacuba exists for a town 17 km north of Tlapanaloya on the northern side of the mountain range that separates the two towns. This must be the mountain range that the grant indicates. The “mesa grande” where the grant is sited likely refers to the only sizeable mesa in the entire mountain range, which is directly south of Ajacuba and separated from that town by mountains as the grant describes.

**44 - Tlapanaloya/1590/Alonso de Galdo Gusman/AGNM v. 15 f. 161v.-162r. (>2 km)**

AGNM v. 15 f. 161v.-162r.: “un sitio de estancia para ganado menor en terminos del pueblo de Tlapanaloya en unas lomas y cerros altos que estan en la derecha de unas quebradas y cuchillos [ridgetops] que llaman de las caleras de Tlapanaloya donde estan unas fuentes y un cedro verde muy alto. A la parte de oriente en la cumbre [summit; top] de las dichas laderas [slopes; hillsides] y cerros por encima de unos pajonales [stubble fields] blancos.” This estancia was located in the mountain range northward of Tlapanaloya. The references to summits and slopes are too general to pinpoint an exact location so I have mapped this estancia almost directly north of Tlapanaloya where lime mining was active.

**45 - Tequixquiac/1591/Diego Mercado/AGNM v. 17 f. 52r.-v. (+/-2 km)**

AGNM v. 17 f. 52r.-v.: “un sitio de estancia para ganado menor que es en un cerro alto.” A contemporary map shows where the estancia was to be sited, on top of the large cerro to the west of Tequixquiac (AGNT v. 2691 exp. 11 f. 9r.-v., MAPOTECA map #1684)

**46 - Hueyoptla/1593/Community of Hueyoptla/AGNM v. 18 f. 278v.-279r. (+/-2 km)**

AGNM v. 18 f. 278v.-279r.: “El dicho sitio de estancia en un llano que corre de norte a sur un poco hondo de agua.” The map that accompanied this merced shows the llano’s location just west of Cuevas (AGNT v. 1532 exp. 4 f. 55, MAPOTECA map #1097).

**47 - Hueyoptla/1593/Community of Hueyoptla/AGNM v. 19 f. 168r.-v. (+/-2 km)**

AGNM v. 19 f. 168r.-v.: “un sitio de estancia para ganado menor en terminos del dicho pueblo en el cerro que llaman Metlaltongo en un xaguey de agua y pegado [closer than beside] a una palma grande y encima cantidad de tunales y de la una banda y otra del dicho puesto hay dos quebradas secas que corre de norte al oriente.” A map from 1756 depicts the area northeast of Hueyoptla and identifies Cerro Metlatongo with a palmar to its southwest (AGNT v. 3256 exp. 1 f. 33, MAPOTECA map #2334). On the north and south sides of Cerro Metlaltongo there are quebradas that run north to east as the grant describes.

**48 - Tequixquiac/1595 (~1535)/Beatriz de Rivera/AGNM v. 21 f. 80v.-81r. (+/-2 km)**

AGNM v. 21 f. 80v.-81r.: Martín López, conquistador and encomendero of Tequixquiac, left his encomienda to his son, Martín López Osorio (Paso y Troncoso 1905 v. 6, 204). This is a title for an estancia granted to Beatriz de Rivera’s conquistador father-in-law sixty years earlier. The estancia is described to be located “. . .en terminos de este pueblo de Tequixquiac donde dicen las troxas en unas llanadas que corren de oriente a poniente y de norte a sur a la puerta de la casa de la dicha estancia y esta una palma silvestre, que por la parte de oriente corre la dicha llanada hasta dar a una arvoleda [grove] y caserías de un sujeto del dicho pueblo nombrado Chiamillpa y por la de el poniente corre la dicha llanada hasta dar a otro sujeto del dicho pueblo que se dice Tlalchco y por la parte del norte esta una quebrada y rrambla grande [watercourse], aguas vertientes a un arroyo de poca agua en la dicha quebrada y rrambla, corre de oriente a poniente y por la de el sur esta baxado de una loma que nombran Las Trojas aguas vertientes a una arroyo corriende al dicho pueblo de Tequixquiac.” Immediately north of Tequixquiac is a llanada that could be interpreted as evincing N-S and E-W trends as the merced describes. The toponym Tlalchco is known to have been between one-quarter (Paso y Troncoso 1905 v. 3, 51) and one-half league to the north (Bernal 1957, 290-1), and given the Christian advocacy San Sebastian (Paso y Troncoso 1905 v 3, 51 note 1; Rodríguez Peláez 1999, 82). Tlalchco, then, is presumed to be the ex-Hacienda San Sebastian, which is about one-half league NNW of Tequixquiac (AGADE exp. 2150 leg. 3, map). When the estancia is placed directly north of Tequixquiac with the ex-Hacienda San Sebastian at its western edge, there is a rambla bounding it to the north and the Salado de Hueyoptla to the south, which corresponds with the merced’s description.

**49 - Tezcatepec/1596/Luis de Soto Cabezon/AGNM v. 22 f. 76r.-v. (+/- 2 km)**

AGNM v. 22 f. 76r.-v.: “el sitio en un cerro y penas altas. detras de las dichas penas en una ensenada y baranca muy honda y por mas arriba hacia el poniente sube un monte.” This location can be interpreted as both a wide barranca as well as a cove because of the circuitous route to get to it.

**51 - Hueypoxhla/1600/Diego Lopes de las Rrobles/AGNM v. 23 f. 87v.-88r. (+/- 2 km)**

AGNM v. 23 f. 87v.-88r.: “un sitio de estancia para ganado menor y dos caballerías de tierra en terminos de los pueblos de Gueypustla y Tolcayuca. El dicho sitio de estancia en el pueblo que llaman Çacacalco en la quebrada que hacen dos cerros que corre de oriente a poniente corriendo por el camino que sale del dicho pueblo de Tolcayuca a Zacacalco a mano derecha antes de llegar a Zacacalco adonde hace una cuchilla [ridgetop] en uno de los dichos cerros que corre de norte a sur.” The toponyms Zacacalco and Tolcayuca are still in use. There is only one quebrada between the two towns that runs E-W. One of the two cerros that bounds the quebrada is elongated in a N-S orientation, which also corresponds to the merced’s description. This location corresponds to the merced’s description that traveling the road from Tolcayuca to Zacacalco the grant will be on the right-hand side before reaching Zacacalco. This grant was eventually aquired by Bernardino de Estrada and is located near others that he owned in the Zacacalco area in the first decade of the seventeenth century (AGNT v. 2704 exp. 30 f. 240r.-276v.).

**52 - Tezcatepec/1600/Gregorio de Soto/AGNM v. 23 f. 113r.-v. (>2 km)**

AGNM v. 23 f. 113r.-v.: “un citio de estancia para ganado menor en terminos del pueblo de Tezcatepec de la parte del norte en una quebrada donde esta una fuentecilla de agua. Linde por la parte del poniente con estancia del dicho Gregorio de Soto dos leguas de distancia hasta lugar del pueblo de Santa Maria.” Two leagues to the north of Santa Maria Ajoloapan places this estancia directly to the east of an estancia granted eleven years earlier to Alonso Ximenez de Portilla (AGNM v. 14 f. 232v.-233v.). Whether Gregorio de Soto had acquired this other estancia by 1600 remains unknown and this estancia’s placement is tenuous.

**53 - Hueypoxhla/1600/Felipe de las Rrobles Quinoñes/AGNM v. 24 f. 28v.-29r. (+/- 2 km)**

AGNM v. 24 f. 28v.-29r.: “un sitio de estancia para ganado menor y dos caballerias de tierra en terminos del pueblo de tolcayuca. El dicho sitio de estancia en el cerro que se llama Xumayuca al pie del en la ladera [slope; hillside] del dicho cerro que esta a mano derecha del camino que viene del dicho pueblo de tolcayuca a el de gueipustla de sur a norte.” The toponym of the cerro, Xumayuca, remains unidentified. However, Hueypoxhla and Tolcayuca are current toponyms. Hueypoxhla’s sujeto Xomeyuca was reportedly two leagues eastward of the cabecera (Paso y Troncoso 1905 v. 6, 27). I have mapped this estancia as the merced describes on the north side of the road that connects Tolcayuca and Hueypoxhla, about two leagues to the east of Hueypoxhla.

**54 - Tequixquiac/1603/Maria Ordoñez/AGNM v. 24 f. 141r.-v. (+/-2 km)**

AGNM v. 24 f. 141r.-v.: “un sitio de estancia para ganado menor con dos caballerías de tierra en terminos del pueblo de Tequisquiaque como una [le]gua del en una loma y canada que corre de oriente a poniente y pasa por la dicha loma un camino que viene del pueblo de Zumpango y entra en el de Tlapanaloya.” Zumpango is directly south of Tlapanaloya and the road that connects them runs along the tops of three lomas that lie directly south of Tlapanaloya, about a legua from Tequixquiac. The cañada the merced refers to is probably the east-west strip of low elevation that separates the two more northerly lomas.

**59 - Tlapanaloya/1606/Sancho Barahona/AGNM v. 25 f. 132r.-133r. (+/-2 km)**

AGNM v. 25 f. 132r.-133r.: “El dicho sitio de estancia y tierras junto a un jaguey pequeno y a un arbole de mesquite, en un pago [rural area or vineyard] llamado Jalmomatla”

AGNT v. 2812 exp. 12 f. 373r.: “el sitio de estancia y las caballerias de tierra en terminos de Gueypustla en una loma”

AGNT v. 1634 exp. 4 f. 22r.: The estancia is said to be “en la juridiccion de Tettepango y Atitalaquia,” which would indicate it is in the northwest section of the study area.

AGNT v. 1634 exp. 4 f. 307r.-308v.: Regarding the estancia, “Linda dicho sitio por la parte del sur con tierras de la dicha hacienda de San Juan Baptista y de los pueblos de Tlapanaloya y Guipustla.” This record also says it touches San Bernabe.

AGNT v. 1557 exp. 1 f. 48 [map]. This map shows both San Juan Baptista and San Bernabe directly north of Tlapanaloya, so the estancia must be north of those haciendas, which border it on the south.

**61 - Tuzantlalpa/1609/Bernardino de Estrada/AGNM v. 26 f. 161v.-162v. (+/-2 km)**

AGNM v. 26 f. 161v.-162v.: Regarding the first estancia, “un sitio hacia a la parte del norte al pie de una loma que corre de oriente a poniente poco mas arriba de la loma. Hacia oriente de unos paredones [large, thick walls] viejos que dicen que antiguamente era sujeto del dicho pueblo de Tuzantlalpa que se llaman San Andres. En unos diez o doce magueyes grandes y dos nopales silvestres que estan junto de un Jaguecillo pequeño seco. Que por la parte del norte el dicho sitio va a dar a una barranca grande que corre de oriente a poniente y por la parte del sur a un arroyo hondo de tierra tepetate que corre asi mismo el oriente a poniente y por la parte del oriente en la dicha loma que viene hasta el dicho sitio y por la del poniente a un llano grande que llaman de San Anton.” The description begins by relating that the grant is in the northern part of Tuzantlalpa’s territory. North of Tuzantlalpa there is only one loma and it runs E-W with a quebrada to its north running parallel to it. The grant is described as being east of the former settlement called San Andres. San Andres is situated the west of the loma (Franco and Becerril 1927; Instituto Geológico de Mexico, 1937), providing a rough western boundary for the grant. The grant’s western boundary is also described as abutting a llano called San Anton, which must refer to the llano directly south of the former Rancho San Antonio (Franco and Becerril 1927).

Regarding the second estancia, “Y el otro sitio de estancia al medio de una loma que corre de oriente a poniente que pasa del cerro que llaman de Aranda que viene corriendo hacia el oriente a dar en un sitio de estancia que llaman de Juan Francisco y en la cumbre del



dicho cerro de Aranda esta un sitio que dicen es del dicho Bernardino de Estrada y la estancia que llaman de Juan Francisco. Ansi mismo dicen ser suya el manera que el dicho sitio cae entre las dichas dos estancias del dicho Bernardino de Estrada en una loma que hace la dicha loma junto al camino Real que viene de Ocutpa [Actopan] a esta sitio a la mano yzquierda del como un tiro de arcabuz [distance of a shot from a rifle] a la [f]alda de dos mogotes pequeños que se hacen de la dicha loma.” Cerro de Aranda does not meet any other topographical features except in its northwestern quadrant where a small E-W trending loma grows out of it, so the grant must be situated on this loma. The road to Actopan ran along the eastern edge of Cerro de Aranda (AGNT v. 3256 exp. 1 f. 33, MAPOTECA map #2334) and this road provides the location of the eastern (or “left” when looking north) section of the grant. By the year the Viceroy awarded this merced Bernardino de Estrada had already acquired two other mercedes originally awarded to Alonso de Mansilla in 1580 and Diego Lopes in 1600 (AGNT v. 2704 exp. 30 f. 240r.-276v.). These two grants flank this grant to the west and east, respectively, and the merced acknowledges that this grant falls between two others the grantee owns. Lastly, the southern boundary is given as “la cañada grande de Zacacalco” and this refers to an area immediately north of Zacacalco where lies the ex-hacienda La Cañada. This grant largely overlaps with one awarded earlier in 1593 to the community of Hueypoxtla (AGNM v. 19 f. 168r.-v.)

**62 - Tezcatepec/1609/Luis de Soto Cabezon/AGNM v. 26 f. 207v.-208v. (+/-2 km)**

AGNM v. 26 f. 207v.-208v.: Regarding the first estancia, “hagemos merced a Luis de Soto Cavezon de dos sitios de estancia para ganado menor con cada dos caballerias de tierra en terminos de los pueblos de Tuzantalpa, Temoaya y Tescatepeque. Un sitio de estancia en una cañada en frente del dicho pueblo de Temoaya en una ladera [slope; hillside] que corre de norte a sur por donde passa el camino que viene del pueblo de Octupa [Actopan] a esta ciudad [Mexico City] a mano derecha y a la izquierda esta una quebrada y dos cerros grandes que el dicho sitio se nombra en lengua Otomi Botoca, y las dos caballerias de tierra hacia arriba a la parte de oriente se nombra en la dicha lengua Otomi Matñuno y en la castellana se dize Santa Catalina.” Temoaya seems to have the same location today as it did in the sixteenth century. This location coincides with this merced’s description of Temoaya as situated on the road that connects Mexico City with Actopan and next to a N-S cañada (Instituto Geológico de Mexico 1937). Furthermore, in Nahuatl Temoaya means “hillside or road that descends” (Vera 1889, 23), which is again consistent with the contemporary location. The toponym Santa Catalina now exists as Santa Catarina (or at some point there was committed a transcription error of one letter), and as the merced indicates is situated eastward of Temoaya (Franco and Becerril 1927; Instituto Geológico de Mexico 1937).

Regarding the second estancia, “y el dicho sitio de estancia en una ladera [slope; hillside] que cae a la falda de un cerro grande a mano derecha corre van hazia el pueblo de Tianguistongo junto a una palma y a mano yzquierda esta el dicho camino y linde con tierras suyas y las dichas dos caballerias de tierra mas arriba como medio legua en una cañada grande que esta entre does cerros grandes en una banda de monte hazia el poniente al pie del monte.” There are two cerros that run towards Tianguistongo, however the grant clarifies the location by stating that the cerro is to the right of the estancia and the Mexico City-Actopan road is to the left of it. Therefore, this estancia was granted on the E-W running slopes of the cerro immediately east of Tianguistongo.

**63** - Tezcatepec/1609/Luis de Soto Cabezon/AGNM v. 26 f. 208v.-209v. (+/-2 km)

AGNM v. 26 f. 208v.-209v.: “un sitio de estancia para ganado menor en terminos del pueblo de Tezcatepeque dentro de sitios y tierras suyas ocupando los baldios que en los sitios y tierras hay en una cañada [low spot between two elevations] y ladera [slope; hillside] que corre de oriente a poniente junto a dos cerros grandes y en la otra parte un xaguey que cae media legua del dicho pueblo.” The cerros that run E-W are in the south of the grant and the jagüey is in the north. The merced describes this estancia to be within lands the grantee already possesses (AGNM v. 22 f. 76r.-v.), so I have aligned this estancia with the one he was awarded in 1596 to the north.

**65** - Tezcatepec/1610/Gregorio de Soto/AGNIV caja 4696 exp. 2 (>2 km)

AGNIV caja 4696 exp. 2: “sitio de estancia esta en terminos del pueblo de Tezcatepeque a la parte del norte en una quebrada donde esta una fuente de agua.” This estancia’s locational description is very nearly the same as the description for an estancia that Gregorio de Soto received ten years earlier (AGNM v. 23 f. 113r.-v.). This could mean that this record of a merced (which I found outside AGN-Mercedes) is a duplicate with an error in the transcription of the year. However, the calendar dates are different as well, so the error is more substantial than an incorrectly copied single digit (the “0” and “1” that are the difference between “1600” and “1610”). The explanation may be that when applying for this later grant Gregorio de Soto drew upon the text of his earlier grant so as to ensure that the estancias would be adjacent. Working under this assumption, then, that this is indeed a discrete merced, I have mapped it adjacent to the earlier one.

## APPENDIX C: ESTANCIA SLOPE AND ASPECT DATA

**Table C.1.** Estancia slope and aspect data

YEAR AWARDED	SLOPE (%)	ASPECT (1 = 8.125 sq. m. area unit)				APPENDIX A REFERENCE
		North	East	South	West	
1535	3.32	102	85	409	365	48
1542	9.26	332	129	178	322	1
1544	1.73	113	40	474	334	2
1544	7.88	64	289	394	214	2
		<b>611</b>	<b>543</b>	<b>1455</b>	<b>1235</b>	
	<b>AVG. 5.55</b>	<b>15.90%</b>	<b>14.10%</b>	<b>37.90%</b>	<b>32.10%</b>	
1559	12.15	266	128	147	420	3
1561	5.2	188	37	529	207	4
1562	11.03	269	261	334	97	5
1562	29.9	175	255	349	182	6
1562	20.91	9	349	512	91	7
1562	12.19	157	371	378	55	8
1563	10.88	193	202	389	177	10
1564	19.44	283	48	84	546	11
1564	8.03	235	279	251	196	12
1568	18.81	207	538	212	4	17
1568	8.83	22	164	495	280	18
1568	11.93	121	303	380	157	19
1568	11.82	31	282	227	421	20
1568	15.96	149	525	271	16	21
1568	14.5	175	167	206	413	24
		<b>2480</b>	<b>3909</b>	<b>4764</b>	<b>3262</b>	
	<b>AVG. 14.1</b>	<b>17.20%</b>	<b>27.10%</b>	<b>33.10%</b>	<b>22.60%</b>	
1577	18.48	311	234	105	311	26
1580	19.79	82	373	350	156	28
1582	1.52	47	389	331	194	29
1583	23.07	168	164	235	394	30
1584	13.64	161	264	58	478	33
1584	15.58	89	25	307	540	34
1585	7.47	630	55	15	261	36
1586	6.35	293	116	216	336	38
		<b>1781</b>	<b>1620</b>	<b>1617</b>	<b>2670</b>	
	<b>AVG. 13.24</b>	<b>23.20%</b>	<b>21.10%</b>	<b>21%</b>	<b>34.70%</b>	

table continued

YEAR AWARDED	SLOPE (%)	ASPECT (1 = 8.125 sq. m. area unit)				APPENDIX A REFERENCE
		North	East	South	West	
1589	3.05	21	570	365	5	40
1589	8.59	557	35	87	282	41
1589	5.76	95	176	347	343	42
1590	29.19	287	278	206	190	43
1590	22.99	189	237	292	243	44
1591	20.29	76	417	254	214	45
1593	3.71	46	222	395	298	46
1593	10.38	108	255	304	294	47
1596	16.13	346	356	133	126	49
		<b>1725</b>	<b>2546</b>	<b>2383</b>	<b>1995</b>	
	<b>AVG. 13.34</b>	<b>19.90%</b>	<b>29.40%</b>	<b>27.60%</b>	<b>23.10%</b>	
1600	15.14	32	234	416	279	51
1600	21.2	364	74	243	280	52
1600	8.01	3	107	583	268	53
1603	6.16	229	272	180	280	54
1606	6.39	11	72	524	354	59
1609	12.13	447	96	75	343	61
1609	13.22	402	302	136	121	61
1609	18.09	350	339	102	170	62
1609	7.46	195	7	222	537	62
1609	16.57	218	471	264	8	63
1610	14.96	358	254	284	65	65
		<b>2609</b>	<b>2228</b>	<b>3029</b>	<b>2705</b>	
	<b>AVG. 12.66</b>	<b>24.60%</b>	<b>21.10%</b>	<b>28.70%</b>	<b>25.60%</b>	

## APPENDIX D: ESTANCIA ELEVATIONAL DATA

**Table D.1.** Estancia elevational data

YEAR AWARDED	RANGE MIN.	RANGE MAX.	AVG. ELEVATION	APPENDIX A REFERENCE
1535	2194	2255	2226	48
1542	2274	2478	2323	1
1544	2298	2343	2323	2
1544	2348	2517	2398	2
	<b>AVG. 2279</b>	<b>2398</b>	<b>2317</b>	
1559	2407	2587	2484	3
1561	2214	2322	2266	4
1562	2524	2722	2617	5
1562	2510	2994	2730	6
1562	2397	2939	2573	7
1562	2406	2581	2478	8
1563	2435	2610	2506	10
1564	2447	2854	2588	11
1564	2567	2756	2650	12
1568	2204	2547	2363	17
1568	2271	2563	2343	18
1568	2270	2560	2339	19
1568	2270	2586	2363	20
1568	2248	2533	2364	21
1568	2408	2667	2515	24
	<b>AVG. 2372</b>	<b>2655</b>	<b>2479</b>	
1577	2237	2567	2419	26
1580	2337	2698	2496	28
1582	2276	2311	2290	29
1583	2317	2755	2481	30
1584	2272	2586	2401	33
1584	2301	2686	2422	34
1585	2349	2668	2435	36
1586	2253	2350	2314	38
	<b>AVG. 2293</b>	<b>2578</b>	<b>2407</b>	

table continued

<b>YEAR AWARDED</b>	<b>RANGE MIN.</b>	<b>RANGE MAX.</b>	<b>AVG. ELEVATION</b>	<b>APPENDIX A REFERENCE</b>
1589	2262	2367	2291	40
1589	2153	2467	2222	41
1589	2353	2540	2423	42
1590	2366	2762	2598	43
1590	2433	2755	2591	44
1591	2310	2586	2463	45
1593	2272	2340	2295	46
1593	2385	2569	2447	47
1596	2339	2688	2600	49
	<b>AVG. 2319</b>	<b>2564</b>	<b>2437</b>	
1600	2348	2713	2439	51
1600	2242	2569	2462	52
1600	2301	2512	2358	53
1603	2248	2344	2302	54
1606	2299	2470	2372	59
1609	2306	2586	2444	61
1609	2382	2695	2474	61
1609	2363	2545	2417	62
1609	2195	2503	2342	62
1609	2445	2857	2627	63
1610	2231	2555	2454	65
	<b>AVG. 2305</b>	<b>2577</b>	<b>2426</b>	

## APPENDIX E: TEXTUAL ANALYSIS OF MERCEDES

**Table E.1.** Siting of estancias

	1535-1544	1559-1568	1577-1586	1589-1596	1600-1610	TOTALS
Llano/llanada	2	1	1	2		6
Cañada	2				2	4
Tierras baldías		1				1
Loma		2	6	1	3	12
Cerro/monte		11		5	2	18
Loma and cerro			1	1		2
Quebrada					3	3
Loma & cañada					1	1

**Table E.2.** Landscape features near estancias

YEAR AWARDED	LANDFORM	CABECERA	APPENDIX A REFERENCE
1562	pedregal	Tuzantlalpa	5
1562	ciénaga	Tezcatepec	8
1568	mogotes de piedra	Tequixquiac	21
1568	piedras	Hueypoxtla	24
1577	pedrisco	Tequixquiac	26
1586	cue antiguo	Tequixquiac	38
1589	pedregalejo	Hueypoxtla	41
1596	barranca muy honda	Tezcatepec	49
1609	barranca grande	Tuzantlalpa	61
1609	arroyo hondo de tepetate	Tuzantlalpa	61
1609	paredónes viejos	Tuzantlalpa	61
1609	mogotes pequeños	Tuzantlalpa	61

**Table E.3.** Landforms near estancias

<b>YEAR AWARDED</b>	<b>LANDFORM</b>	<b>CABECERA</b>	<b>APPENDIX A REFERENCE</b>
1535	llanada	Tequixquiac	48
1542	cañada	Tequixquiac	1
1544	cañada	Hueypoxtla	2
1544	llano	Hueypoxtla	2
1559	tierras baldías	Tuzantlalpa	3
1561	llano	Tlapanaloya	4
1562	loma	Tuzantlalpa	5
1562	cerro	Hueypoxtla	6
1562	monte	Hueypoxtla	7
1562	cerro	Tezcatepec	8
1563	cerro	Tuzantlalpa	10
1564	loma	Tuzantlalpa	11
1564	cerro	Tuzantlalpa	12
1568	cerro	Tequixquiac	17
1568	cerro	Tequixquiac	18
1568	cerro	Tequixquiac	19
1568	cerro	Tequixquiac	20
1568	cerro	Tequixquiac	21
1568	cerro	Hueypoxtla	24
1577	cerro	Tequixquiac	26
1580	cerro	Hueypoxtla	28
1582	llanada	Hueypoxtla	29
1583	cerro	Apaxco	30
1584	cerro	Tequixquiac	33
1584	cerro	Hueypoxtla	34
1585	cerro	Tezcatepec	36
1586	loma	Tequixquiac	38
1589	loma	Tequixquiac	40
1589	cerro	Hueypoxtla	41
1589	llano	Tezcatepec	42
1590	monte	Tlapanaloya	43
1590	lomas y cerros	Tlapanaloya	44
1591	cerro	Tequixquiac	45
1593	llano	Hueypoxtla	46
1593	cerro	Hueypoxtla	47
1596	cerro	Tezcatepec	49



table continued

<b>YEAR AWARDED</b>	<b>LANDFORM</b>	<b>CABECERA</b>	<b>APPENDIX A REFERENCE</b>
1600	quebrada	Hueypoxtla	51
1600	quebrada	Tezcatepec	52
1600	cerro	Hueypoxtla	53
1603	loma y cañada	Tequixquiac	54
1606	loma	Tlapanaloya	59
1609	loma	Tuzantlalpa	61
1609	loma	Tuzantlalpa	61
1609	cañada	Tezcatepec	62
1609	cerro	Tezcatepec	62
1609	cañada	Tezcatepec	63
1610	quebrada	Tezcatepec	65

**Table E.4.** Vegetation references in the mercedes

<b>YEAR AWARDED</b>	<b>VEGETATION</b>	<b>CABECERA</b>	<b>APPENDIX A REFERENCE</b>
1563	monte	Tuzantlalpa	10
1563	palmar	Tuzantlalpa	10
1564	tuna grande	Tuzantlalpa	11
1566	tunas grandes	Tezcatepec	16
1568	tunales silvestres	Tequixquiac	17
1568	cerecedas	Tequixquiac	19
1568	sauce	Tequixquiac	20
1568	tunas	Hueyboxtla	24
1585	palmar	Tezcatepec	36
1586	magueyes silvestres	Tequixquiac	38
1589	tunales silvestres	Hueyboxtla	41
1590	cerro verde muy alto	Tlapanaloya	44
1593	capulines	Hueyboxtla	46
1593	magueyes silvestres	Hueyboxtla	46
1593	palma grande	Hueyboxtla	47
1593	cantidad de tunales	Hueyboxtla	47
1600	pirul	Hueyboxtla	51
1604	monte	Apaxco	57
1604	arboles de espinas	Apaxco	57
1606	arbol de mesquite	Tlapanaloya	59
1609	magueyes grandes	Tuzantlalpa	61
1609	nopales silvestres	Tuzantlalpa	61
1609	monte	Tezcatepec	62
1609	palma	Tezcatepec	62

**Table E.5.** Hydrological references in the mercedes

<b>YEAR AWARDED</b>	<b>HYDROLOGICAL FEATURE</b>	<b>CABECERA</b>	<b>APPENDIX A REFERENCE</b>
1544	jagüeyes	Hueypoxtla	2
1561	arroyo de agua	Tlapanaloya	4
1568	jagüey	Tequixquiac	20
1584	jagüey viejo	Hueypoxtla	34
1589	aguas vertientes	Tezcatepec	42
1590	fuentes	Tlapanaloya	44
1593	poco hondo de agua	Hueypoxtla	46
1593	dos jagüeyes secos	Hueypoxtla	46
1593	jagüey de agua	Hueypoxtla	47
1593	dos quebradas secas	Hueypoxtla	47
1600	fuentesilla de agua	Tezcatepec	52
1600	jagüey seco	Hueypoxtla	53
1603	arroyo seco	Tequixquiac	55
1604	arroyo seco	Apaxco	57
1606	jagüey pequeño	Tlapanaloya	59
1606	fuentesilla de agua	Hueypoxtla	60
1609	jagüey pequeño seco	Tuzantlalpa	61
1609	jagüey	Tezcatepec	63
1610	fuelle de agua	Tezcatepec	65

## VITA

Richard Hunter was born in Corona, California, in 1980. At age 11 he moved to a rural South Dakota town and this change in his social and biophysical environments sparked his interest in geography. From South Dakota State University in 2001 he received a Bachelor of Arts degree in history and a Bachelor of Science degree in geography, and in 2003 a Master of Science degree in geography. He earned his doctoral degree in geography in May 2009 from Louisiana State University. His current research interests concern historical, environmental, and Latin American geography.