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The Children of Mayahuel:

Agaves, Human Cultures, and Desert Landscapes in Northern Mexico

Abstract

This article brings together research in ethnobotany, ecology, and history to show the mutually reinforcing relations between humans and agaves. Its theoretical framework integrates three foundational concepts relating to the production of space, the evolution of life-forms, and the creation of desert landscapes. Centered on the mutually formative relations between the agave family of plants and both indigenous and colonial populations in northern Mexico, this study challenges the conventional distinction between wild and cultivated plants and addresses different modes of cultural diffusion between Mesoamerica and the arid lands of the Sonoran and Chihuahuan deserts. Its aim is to relate the botanical complexities of the Agaveae to the development of different systems of knowledge and cultural beliefs relating to the plant and to the historical communities that have intervened in its cultivation and distribution.

The uses of agaves are as many as the arts of man have found it convenient to devise.
—Howard Scott Gentry, *Agaves of Continental North America* (1982)

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Introduction

Inspired by H. S. Gentry's affirmation linking human creativity to the uses of agave and to the distributional patterns of different species, this article brings together botanical, historical, and anthropological research on the agave family of Mesoamerica and northern Mexico. Its purpose is to show the mutually reinforcing relations between humans and agaves and to relate the botanical complexities of the plant to the development of knowledge about agaves among both Amerindian and European sources. It argues that the distribution of biomes helps us to understand the production of historical spaces and their cultural meanings as these evolve in the discernible relationships between peoples and plants. This study challenges the conventional distinction between "wild" and "cultivated" plants, focusing on the Sonoran and Chihuahuan deserts, arid lands that are surrounded by grasslands and scrub forests and intersected by river systems and mountainous terrain that mark the western and eastern ranges of the Sierra Madre. It addresses the different modes of cultural diffusion between Mesoamerica and the northern deserts during the pre-Hispanic era, and it points to the contrasts and continuities between the indigenous meanings and uses of agaves and their expression in the colonial and modern periods.

The theoretical frameworks that guide our discussion combine the production of space, the concept of life-forms, and the cultivation of desert landscapes. Building on Henri Lefebvre's theories of the social production and representations of space, this study emphasizes the role of human labor in the botanical evolution of agaves as well as the religious and scientific import of the representations of agaves that emerge from both native American and European cultures. Lefebvre's thesis interpreted socially produced spaces such as tilled fields and managed pastures, terraced hillsides and irrigation works, towns and urban centers.[1] In arid lands traversed by nomadic peoples, we can see the social production of space in harvested stands of saguaro cacti, ephemeral weirs built across streambeds to capture the runoff of seasonal rainstorms, or the smoked pits dug for roasting agave leaves and hearts.

Representational spaces refer to the hermeneutics of humanly crafted spaces that evince ceremonial, political, or religious values, such as cathedrals, temples, pyramids, or the *kivas* of Puebloan peoples in the American Southwest. Less visible, but equally endowed with meaning as representational spaces, are the simple ramadas erected for ceremonial dances or the processional routes that are reenacted seasonally for religious observances. In Lefebvre's framework, representations of space refer to images and textual descriptions of specific places or regions through figurative scales and symbols of geographic features and human settlements.

Indigenous cosmologies of the Americas render representations of space in the codices that depict calendrical cycles and deities as well as in the petroglyphs chiseled in caves and hillside terraces or the figures of decorated ceramics, weavings, and baskets.

The "spatial turn" that Lefebvre's work inspired has typically been applied to urban phenomena in the creation of public spaces or to the transformation of rural spaces into manorial estates and peasant agricultural villages.[2] This article relates the production of space to the nomadic cultures of northern Mexico through the interventions of different tribal and colonial peoples in the distribution and species variation of plant communities. Through the representations of space found in images, legends, and botanical knowledge of agaves, it integrates the material production of space with the perceptions of desert landscapes in pre-Hispanic, colonial, and modern histories.

The concept of life-forms complements the production of space, focusing on the convergence of functions and adaptive strategies among different organisms that interact in arid-lands biomes.[3] Life-forms overlay the botanical categories of phyla, genera, and species by grouping plants according to their observed strategies for survival: for example, the breadth and depth of root systems, succulent stems and leaves that store water, or microphyllous plants (with tiny leaves) that minimize loss of water through evapotranspiration. Strategies are discerned through patterns of "interaction of the life form with the environment over thousands of years," creating horizontal linkages across distinct species occurring in desert ecosystems that share adaptive features.[4] This article uses the concept of life-forms to build vertical linkages across time that explicate the mutual development of societies and plant communities.

Joining these two conceptual frameworks, this article brings together evidence from diverse fields of study on the intersection of natural and cultural processes in the reproduction and differentiation of agave species. Organized in broad chronological periods, it covers desert landscapes, agave taxonomies in different knowledge systems, and the historically evolved relations between agaves and people. It shows that plant communities sustain human life at the same time that they evolve through overlapping livelihoods, modes of social organization, belief systems, technologies, and patterns of conflict. Our discussion moves through different classification systems referring to the agave family, the qualities of selected agave species, and the evidence culled from archaeology, history, and ethnography for documenting the combined techniques of cultivating and gathering agaves. The conclusions return to the ways in which human societies shape desert environments, harvest their fruits, and spin webs of knowledge about the natural world, pointing to changes over time and in space.

Cultural Perceptions of Deserts

In desert climates, rates of evapotranspiration exceed precipitation; for those who live in them, deserts are lands of little rain, snow, or dew. Desert conditions refer not only to rainfall and temperature but also to the texture and composition of soils and geological features like shallow soils on rocks or sandy soils that retain little water. The aridity of the Sonoran and Chihuahuan deserts arises from their separation from oceanic sources of moisture, compounded by the drying effect of air masses moving over a mountain barrier and air currents that become warmer and drier as they descend toward the earth's surface.[5]

Grafted onto these geographic and biological determinants of desert climates, the concept carries important historical and cultural meanings. The Tohono O'odham of northwestern Sonora referred to their homeland as "the shining desert," an environment they continue to claim through religious rituals and subsistence practices. Notwithstanding the summer heat and prolonged dry seasons, the Tohono O'odham found life-sustaining resources in plants like the cholla, mesquite, and saguaro; wild game ranging from deer and birds of prey to rodents and reptiles, and the springs and seepage that formed in the fissures of hills and low-lying rocky slopes.[6] They produced spaces in their surroundings through seasonal migrations to three different ecological niches: the groves of saguaros, whose fruit ripened just before the onset of summer storms in July; the fields (*oidag*), where lowland arroyos and washes briefly overflowed with the runoff from summer rains, providing a short cultivation season for beans and amaranths; and the wells (*wahia*) on the hillside slopes for the winter season of hunting and gathering.[7] Desert-dwelling Tohono O'odham bolstered their livelihood through trade with the Akimel O'odham, agriculturalists who occupied floodplain land from the Gila River system in the north to the southern arc composed of the San Pedro, Santa Cruz, Magdalena, and Altar-Concepción drainages, forming the province that Spaniards would name Pimería Alta.

Following Iberian contact, Spanish chroniclers described desert-like regions according to the modes of settlement they found there. Early sixteenth-century explorers contrasted the settled agricultural valleys with surpluses of maize to the *despoblados*—uninhabited spaces without discernible communities—fraught with danger.[8] The Iberian invaders soon learned that the despoblados were, in fact, well populated by nomadic bands who moved over the land in deceptively small numbers according to the seasons for hunting and gathering desert blooms, shoots, and seeds. Their aridity contrasted with the Mesoamerican tropics of central Mexico, and thus early European chroniclers perceived them to be lacking in permanent sources of water, regularly spaced croplands, and sedentary villages.[9]

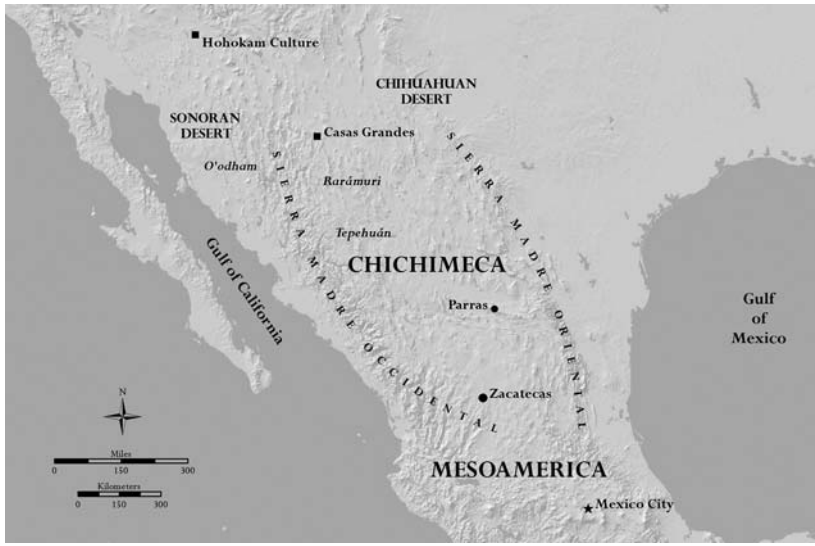


Figure 1: Northern New Spain Location and Relief Map. Credit: Cartography by Jeffrey A. Erbig, Jr.

These climatological, geographic, and historical points of reference characterize the arid lands of northern Mexico, a region with vegetation that varies from tropical deciduous forests to the succulents, cacti, and xerophytic shrubs and trees of the Sonoran and Chihuahuan deserts. The seminomadic and nomadic peoples who lived in this region, traveled through it, and traded with the farming peoples of the surrounding valleys and basins shaped its contours and contributed to the changing composition of its biomes. Focusing on the Agaveae family helps us to understand the adaptive techniques people develop to produce cultural landscapes in deserts.[10]

Natural and Cultural Evolution of Agaves

Agaves are succulent plants with short stems (rosettes); the leaves grow spirally from the rosette as thick *pencas* or elongated triangles. In most species the leaves are spiny with protective teeth that guard the flowering stalks and the fibrous stem and leaf bases from predator animals (including domestic livestock). Both historical and contemporary sources emphasize the length of time it takes the plant to mature (eight to twenty years), the longevity of the leaves (twelve to fifteen years), and the spectacular, usually onetime inflorescence: the central stalk that emerges from the mature rosette and, in two to four months, may reach as high as 10 meters above ground. Agave flowers attract bats, birds, and insects that serve as pollinators, thus

propitiating the formation of seeds. Following the flowering and seeding, the leaves of the parent rosette wither and die. Most agave species, however, reproduce both sexually (by seeds) and asexually through vegetative offsets or suckers that develop just above the roots at the base of the stem. Called *hijos* in Spanish, these "children" constitute the more successful reproductive strategy in many species.[11]

Relationships between humans and agaves in the Americas evolved over nine millennia, beginning in the botanical hearths of Mesoamerica. Archaeological remains from as early as 7000 BCE have documented traces of agave in human coprolites, artifacts, and tools, ranging from Oaxaca to Tamaulipas.[12] The wide variety of uses found for agaves is closely linked to the breadth and diversity of its species, for agaves provide food in their flowers, stems, and bases of their leaves that are seared in an open fire, boiled, or baked in pits. Agave fibers are woven into cordage, nets, bags, baskets, mats, blankets, clothing, and sandals. The botanist Howard Gentry hypothesized that "the many evolving varieties and forms of *Agave* species were selected by man, moved from place to place with him, and inadvertently crossed." Different tribal peoples experimented with new varieties and selected agaves "for yield and quality of fiber, food, beverage," and to satisfy other needs.[13] Thus, over long periods of climatic and historical evolution, both agriculturalists and hunter-gatherers contributed to agave diversification at the same time that their cultural and technological skills became more specialized.

These basic descriptions of agaves rely on the terminology associated with the Linnaean classification system that is familiar to botanists in different international settings today. This is not the first or the only taxonomy, however, in which agaves have figured as a cluster of plants with distinguishing characteristics. Different classification systems establish points of reference for understanding the historical and biogenerative processes through which plant communities are produced, distributed, and transformed. The earliest such system that survived in the documentary record for Mexico was generated through the Nahuatl language and referenced in European scientific literature from the sixteenth to the eighteenth century.[14] Distinct hypotheses concerning the origins and distribution of agaves as cultivated and wild plants in Mesoamerica and the Gran Chichimeca, arising from different languages and modes of scientific inquiry, have their roots in the Nahuatl corpus of knowledge.[15] Historical and legendary connections between Mesoamerica and the northern environments paralleled the ecological and cultural linkages between these distinct regions of greater Mexico, underscoring the Uto-Aztecan linguistic chain of languages and the diffusion of knowledge through multiple channels.[16]

Agaves in Different Knowledge Systems

> *Modern genetics and the fugitive concept of species appear to complicate rather than resolve the Agave species problem.*
> —Gentry, *Agaves of North America* (1982)

Scientific knowledge about agaves originated with indigenous oral traditions and pictographs produced in Mesoamerica. Nahuatl nomenclature for the agaves began with the root word *metl* and differentiated among species or varieties according to their uses, physical characteristics, and whether they grew in "hot" or "cold," lowland or highland, humid or arid environments. Ancient Mesoamericans' interest in agaves went beyond their material utility to their perceived spiritual potency, related to the fermentation of their natural juices (*aguamiel*) turned into *pulque* and personified in the deity Mayahuel, who represented fertility and the arts of weaving.[17]

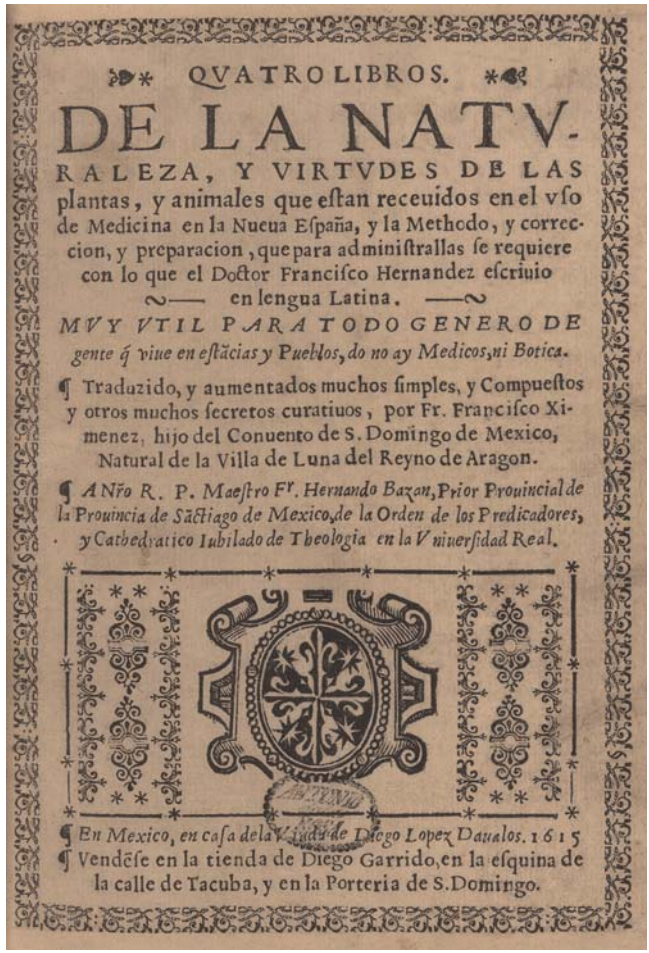
According to several different mythical streams, Mayahuel was transformed into the agave plant after her abduction by the wind god Ehecatl, leading to her violent death. She carried fiber rope, symbolizing her creative skills, and bird-like creatures or human infants suckled at her breast, perhaps alluding to the winged creatures who feed on the nectar of agave flowers. Mayahuel also figures as the mother of Centeotl, a youthful maize deity, thus placing the family of agaves midway between the vegetation of the *monte* and the domesticated crops of Mesoamerica. Her husband, Pahtecatl, infused the maguey juice with its intoxicating powers to produce pulque, a drink with deep roots in the sociability of Mesoamerican nobility and in the religious rituals of central Mexico.[18] In colonial times pulque became available to the common people. More than ten species of wild agaves, as well as six cultivated species, yield varieties of aguamiel that can be fermented or distilled to produce *mescal*. Distilling came into use after European colonization, and, in recent times, mescal became part of Mexican rural drinking cultures from Sonora and Tamaulipas to Oaxaca.[19]

Knowledge about agaves traveled through the translation of Nahuatl systems of classification into Latin and Spanish, radiating from Mexico to Spain, Italy, and northern Europe. The foundational source for colonial botany in Mexico, including the names and descriptions for agaves, came from the monumental *Natural History of New Spain* compiled by Francisco Hernández in the 1570s. As *protomédico* for King Phillip II, Hernández traveled in Mexico for the better part of a decade, learning Nahuatl, collecting specimens, and gathering information on local medical customs, horticulture techniques, and descriptions of plants, animals, and minerals. His observations, written in Latin, filled six folio volumes, identifying more than three thousand plant species, and was accompanied by ten folio volumes of paintings rendered by

Figure 2: In the upper portion of this illustration from Códice Fejérváry-Mayer, a pre-Hispanic book of moral codes from the Nahua culture of central Mexico, the agave plant appears in the guise of Mayahuel, one of the patrons of childbirth, as she nurses a child. Credit: Códice Fejérváry-Mayer, Plate 28. National Museums, Liverpool, M/12014. The Codex was published in Ferdinand Anders, Maarten Jansen, and Luis Reyes García, eds. *El libro de Tezcatlipoca, Señor del Tiempo. Libro explicativo del llamado Códice Fejérváry-Mayer*. (Austria: Akademische Druck-und Verlagsanstalt, México: Fondo de Cultura Económica, 1994), I: 76–77.

indigenous artists. Upon returning to Spain, his scientific work, developed with Nahua collaborators, was poorly understood, and his materials remained unpublished, stored in the Escorial convent and royal palace. Scholars copied and translated portions of his manuscript, but it was not published in its entirety, and tragically, the original texts and paintings perished in the Escorial fire of 1671.[20]

Hernández's expedition to New Spain and his involvement with Nahua science grew out of an increasing interest in empirical knowledge in the court of Phillip II, linked in turn to the commercial traffic between Spain and its American colonies. No doubt, Hernández's training as a physician and the preoccupation with disease in the metropolis and its overseas possessions led him to seek the medicinal properties of all kinds of plants in New Spain, including the family of agaves. Hernández himself observed plants in different seasons, smelled and tasted them, and compared the wisdom of different experts before including them in the selection of specimens to be painted.[21]


QVATRO LIBROS.

DE LA NATV-
RALEZA, Y VIRTVDES DE LAS
plantas, y animales que eſtan receuidos en el vſo
de Medicina en la Nueua Eſpaña, y la Methodo, y correc-
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en lengua Latina.

MVY VTIL PARA TODO GENERO DE
gente q̃ viue en eſtãcias y Pueblos, do no ay Medicos, ni Botica.

¶ Traduzido, y aumentados muchos ſimples, y Compueſtos
y otros muchos ſecretos curatiuos, por Fr. Franciſco Xi-
menez, hijo del Conuento de S. Domingo de Mexico,
Natural de la Villa de Luna del Reyno de Aragon.

¶ *A Nño R. P. Maeſtro Fr. Hernando Bazan, Prior Prouincial de*
la Prouincia de Sãctiago de Mexico, de la Orden de los Predicadores,
y Cathedratico Iubilado de Theologia en la Vniuerſidad Real.

¶ *En Mexico, en caſa de la Viuda de Diego Lopez Daualos. 1615*
¶ Vendeſe en la tienda de Diego Garrido, en la eſquina de
la calle de Tacuba, y en la Porteria de S. Domingo.

Figure 3: Title page for Fr. Francisco Ximénez, *Quatro Libros de la Naturaleza y virtudes de las plantas, y animales que están recevidos en el uso de Medicina en la Nueva España . . . con lo que el Doctor Francisco Hernández escribió en lengua Latina* (Mexico City, 1615). This abridged translation of Francisco Hernández's *Natural History of New Spain* made it available to a wider reading audience in Mexico, where it was published, and in Europe. The original multi-volume work was written in Latin and unpublished. Credit: The John Carter Brown Library at Brown University.

Francisco Ximénez, a Dominican friar, published a synopsis of Hernández's work in Spanish, appearing in Mexico City in 1615.[22] Ximénez's abridged version of Hernández's oeuvre identified eighteen different species by their Nahuatl names, with detailed descriptions of their uses and all parts of the plants. Ximénez provided a succinct description of *metl*, in which he emphasized the size of the leaves (*pencas*) whose edges were covered with thorns, the height of the stem from which the flowers emerged, the size and coarseness of its

root, and the reproduction of the plant through vegetative offshoots.[23] This section of the *Natural History* began as follows:

> Of no other plant is there such abundance in New Spain. If people would learn to live in moderation and balance, as is reasonable, this plant would be sufficient to supply all human needs, for the benefits and uses that come from it are almost innumerable; because the whole plant serves as a fence or barrier to protect one's property, the leaves serve as roof tiles, the stems can be used as beams, and from the leaves one can spin thread to make fibers for clothing, much as we use linen, flax and cotton, and the spines can be turned into nails, needles, and . . . points for weaponry.[24]

Hernández's rendering of Nahua classifications of agave illustrates the close relationship between indigenous technique and the evolution of agaves as shown in table 1. Nearly all of the varieties named by Hernández and his Nahua tutors were composed of the root word *metl* and a descriptive prefix, indicating the physical appearance of the plant, the place where it was found or typically grew, and its beneficent qualities.

Antonio Nardo Recchi published a larger, more ambitious volume of Hernández's Latin text in Rome in 1651 that contained many engraved illustrations of the plants and animals described. Entitled "Thesaurus of the Medical Things of New Spain: Of Mexican Plants, Animals, and Minerals," this impressive tome, graced with an elaborate baroque title page, acknowledged Francisco Hernández as the author (if not his Nahua interlocutors).[25] As knowledge of the agave family of plants circulated in Europe, thanks to Nardo Recchi's publication in Latin, the idea persisted that the agave could supply the basic needs for food, shelter, clothing, tools, and crafts as well as sweeteners and fermented drinks.

Two eighteenth-century German theses, authored by Johannes Henricus Schulze (1723) and Frederik Ruysch (1733), reproduced the ideas from Hernández's transcriptions of Nahua science. Interestingly, both authors grouped together the agave and aloe that in the Linnaean botanical system are assigned to different families of plants (Agaveae and Liliaceae). Focused primarily on their medicinal qualities, both scientists underscored the special virtues of what they called the American aloe, distinguishing its slow pattern of growth and the time it takes to mature, its adaptation to many different climates and types of soils, and its multiple uses and benefits. Schulze had the grace to cite Francisco Hernández, paraphrasing his declaration that no other plant could so abundantly satisfy all human needs.[26] Both authors described different varieties of *alöen* on all of the continents of the world, but they referred to the qualities of *Aloës Americanae* as originating uniquely in the Western Hemisphere.

Table 1: *Metl*: Its Description and Uses in Mesoamerica. Credit: Data from Ximénez, *Cuatro Libros*, 1615: 147–150.

Nahuatl	Spanish	Description and uses
Metlcoztli Costic-metl Macoztic metl Beuti metl	Maguey amarillo Maguey de grande utilidad	Leaf edges are yellow Cooked leaves have medicinal properties
Mezcalmetl	Mescal maguey	Small thorny maguey; leaves roasted for food
Mezcocotl	Maguey de ciruelas	Valued for its fruit; sweet/sour in taste
Nequametl	Bebedora de miel	Grows in the hot tropical regions of Mexico; fruit compared to small pears
Mexoxoctli	Maguey verde	Noted for its green color[68]
Nexmetl	Maguey cenicienta	Described by its color, resembling ashes
Quauhmetl	Maguey montano	Fibrous root and thick stem
Huitzitzilmetl	—	Porous leaves; red-tinged roots and thorns
Tepeyametl	Maguey de Tapayaxin	Similar to huitzitzilmetl
Acametl	Maguey de caña	White root and red thorns
—	Maguey negro	Named for its color; root and thorns are brown
Tepemexcalli	Otro maguey montano	Used to cure paralysis; grows on rocky slopes
Tlacametl	Otro maguey amarillo	Large plant; restores strength to women
Teometl	Maguey del vino, Maguey de Dios	Its juice can cure fevers
Pati	Maguey lenissimo	Source for fiber known as *pita*
Quetzalichtli	Maguey de pita	Source of finer thread for weaving clothing
Xolometl	Maguey de cierbo	Three-part root; red fibers; curative properties

Ruysch and Schulze represent a kind of generational bridge between early modern approaches to science that remained linked to cultural sensibilities and the modern frameworks for scientific research that tended to separate human agency from the natural environment in their commitment to the systematization of knowledge.[27] Botanists and geographers working within the structures of phyla, genera, and species recognized a multitude of agave types and

Figure 4: Title page for Nardo Antonio Reccho, *Rerum medicarum novae hispaniae thesaurus seu plantarum animalium mineralium mexicanorum* (Rome, 1651). Note the Habsburg dynastic shield hanging above the banner that contains the book's title, and the map of central Mexico enclosed between the columns at the lower center of the edifice. The book introduced the medical knowledge of New Spain to the world through Spain's overseas empire. Credit: The John Carter Brown Library at Brown University.

Figure 5: These botanical drawings depict five varieties of metl, the agave family of plants, which were named and classified by Francisco Hernández, and are shown in Table 1 of this article. The drawings offer detailed images of individual plants' leaves, stems, roots and, for the nequametl, its seeded inflorescence. Nardo Antonio Recchio, *Rerum medicarum novae hispaniae thesaurus* (Rome, 1651): 272–273. Credit: The John Carter Brown Library at Brown University.

lineages. Carl Linnaeus first named the genus in 1753, specifying four species; subsequent European collectors multiplied the number of ornamental and horticultural varieties but often without uniform criteria for naming these categories or preserved specimens.[28] Beginning in the last quarter of the nineteenth century, North American taxonomic research on agaves, centered in the Missouri [Henry Shaw] Botanical Garden of St. Louis, augmented European efforts to produce more than four hundred combinations of genera and species for Agaveae in Europe and the Americas.

Working with this heritage, Howard Scott Gentry (1903–93) simplified these taxonomic schemes, producing a structure with two subgenera—Littaea and Agave—each divided into sections, species, subspecies, varieties, and forms. Gentry carefully identified the geographic origin of the specimens on which he based his system, yet he cautioned readers concerning the fungibility of species categories that attempted to distinguish among "populations with fuzzy edges" (see Table 2).[29] His categories use the Latinate lexicon that was developed by European

Table 2: *Agaveae* and its Subdivisions. Credit: Data from Gentry, 1982: xii.

	Section	Species	Subspecies	Varieties	Formae	Total
Subgenus Littaea	Amolae	8		1		9
	Choritepalae	3				3
	Filiferae	8				8
	Marginatae	21			7	28
	Parviflorae	4	2	1		7
	Polycephalae	5		2		7
	Striatae	3	1			4
	Urceolatae	2	1	2		5
Subgenus Agave	Americanae	6	5	8		19
	Campaniflorae	3				3
	Deserticolae	10	11			21
	Crenatae	6	1	1		8
	Ditepalae	10	2			12
	Hiemiflorae	12				12
	Marmoratae	4				4
	Parryanae	6		4		10
	Rigidae	12		7		19
	Salmianae	5	1	3		9
	Sisalanae	6				6
	Umbelliflorae	2	1			3
	Totals	136	25	29	7	197

botanists, with descriptive references to the rosettes, stems, leaves, and flowers of different varieties of agaves and to the processes of maturation and reproduction. Gentry's detailed drawings and descriptions of each of the agave taxa are based on museum and herbaria collections and his own field observations, including local names for the species and varieties he identified.[30] Gentry's work joined that of Mexican botanists and international teams of scientists who have contributed to the ethnobotanical knowledge about agaves and their significance for specific regions and populations.[31]

Species in each subgenus share characteristics and, at the same time, exhibit highly varied formations over the long life of the plant. Referring to table 2, both subgenera Agave and Littaea occur in the major regions of North and Central America, including wild species and those known to be cultivated for economic purposes and local uses.[32] The Marginatae section of the Littaea subgenus favors tropical environments, extending from the Chihuahuan Desert through southern Mexico and into Guatemala. Within this group, however, the xerophytic *A. lechuguilla* occurs throughout the northern Chihuahuan Desert (New Mexico and Texas), Coahuila, San Luis Potosí, and in central Mexico. *A. lechuguilla* reproduces mainly through vegetative offsets; its leaves are poisonous to cattle and other ungulates, which has protected this species of Littaea. Mexicans collect the leaves and leaf buds from wild stands of lechuguilla to extract the fiber from which they manufacture brushes, rope, and twine.[33]

The largest section of the Agave subgenus, Deserticolae, is concentrated principally in Baja California, with *A. deserti* and *A. cerulata* among its most well-known and widely distributed species.[34] In the mainland Sonoran Desert and northern Sierra Madre Occidental, *A. shrevei*, *A. colorata*, and *A. palmeri* figure among the best known species of the Ditepalae section, characterized by their flowers. Ecologically, Ditepalae agaves have evolved as outbreeders through seeding; relying less than other species on vegetative reproduction, they typify the agave–bat symbiosis for flowering and pollination. Culturally, Ditepalae species have proliferated together with diverse indigenous groups of both Uto-Aztecan and Athapaskan tribal origins, valued as sources of fiber, food, medicines, and beverages.[35]

Tables 1 and 2 represent taxonomic systems and ways of thinking about nature that are separated by more than three centuries. They both describe the physical characteristics of different types of agaves and encode that content in the names assigned to each taxa, whether in Nahuatl or Latin. Both sources recognized the different means of reproduction observed for agaves through seeding and vegetative offshoots. Yet a comparison of these two systems reveals their different conceptual frameworks. Francisco Hernández listed different plants separately because he learned their names from his Nahua collaborators but without placing them in a hierarchy. He approached his

task not so much to establish a phylogenetic sequence but to distinguish among the properties of different varieties of maguey as these were meaningful for the historical communities among whom he lived and worked. Although Hernández did not distinguish between cultivars and wild agaves, his reference to magueys as fences to protect villagers' property suggests their deliberate placement near cultivated land; conversely, his use of the term *maguey montano*—referring to mountainous or arid lands beyond the irrigated valleys favored for crops—infers that these types of maguey grew in the wild, where their leaves, roots, and shoots were gathered.

Gentry, by way of contrast, worked within the Linnaean hierarchical taxonomy. Although his research emphasized the cultural dimension of the evolution of plant life, contributing to ethnobotany in important ways, the central problem that his work addressed dealt with the adaptations of different agave taxa to their environment. Gentry—in tandem with modern botanists who developed the concept of life-forms—sought explanations for the variety of plants in their different "strategies for survival," fitness for their habitats, and in the competition among species for soil nutrients, sunlight, and water.

The concept of life-forms, as previously explained, enriches structural taxonomies in order to understand the processes of species adaptation and the ecological contexts in which they develop. Arid-lands botanists began developing the life-form systems of classification with Douglas MacDougal's work on the Sonoran Desert in the early twentieth century, based on the seasonal appearance of plants and distinguishing among ephemerals and perennials, deciduous plants, succulents, and types of roots and tubers.[36] At midcentury, Forrest Shreve and Ira Wiggins expanded on MacDougal's system, defining life-forms in terms of the relationships among plant communities, with particular attention to the stages of adjustment between plants and the environment.[37] Working within the same scholarly community, Frank S. Crosswhite and Carol D. Crosswhite modified the system established by Shreve and Wiggins, interpreting each life-form as a separate strategy for plant survival. They hypothesized that the variety of life-forms observed in the Sonoran Desert, using clusters of resources, may have developed through the trial migrations of different specialized plants: "Through such processes the myriad of desert life-forms have apparently partitioned and repartitioned the Sonoran Desert, resulting in more efficient utilization."[38] And, we may add, plants have migrated with people.

Agaves and Humans in Desert Landscapes

The speciation of agave illustrates the symbiosis of plants and humans; moreover, their reproduction exemplifies the beginnings of

agriculture in the Americas. Less intricate than seed selection and germination, digging up and transplanting offsets or new shoots of agave provided seminomadic peoples with food, fiber, and moisture as they moved from one seasonal encampment to another. Geographer Carl O. Sauer argued over half a century ago that agaves and other root crops sustained a transitional zone between gathering and horticulture.[39] Homer Aschmann observed these principles in the Central Desert of Baja California and the arid lands of northeastern Arizona, noting that the Cochimí peoples of the internal peninsula of California feasted on the sweetened fruit of the pitahaya in the late summer and early fall, but the single most consistent source of nourishment throughout the year came from several edible species of agave that grow in all parts of the Central Desert. The Cochimís roasted the agave hearts, filled with bitter juice, turning them "into a sweet, savory, nourishing dish"; once roasted, agave hearts could be transported and stored.[40] In the riverine valleys and arid slopes along the middle Verde drainage of Arizona, the Yuman Yavapais and the Athapaskan Western Apache relied on gathering agaves, available throughout the year, which required the labor of cutting, transporting, and pit baking.[41]

Biological research on northern Mexico emphasizes the adaptability of agaves to aridity through natural selection, and ethnobotanical studies point to the uses that nomadic peoples make of wild agave stands. Several Deserticolae species (subgenus Agave in table 2) illustrate life-form adaptations to highly uneven rainfall, extreme temperatures, and extended periods of drought through strategies associated with nocturnal carbon fixation. This process produces most of the plant's biomass at night, minimizing moisture loss during the intense heat of desert daylight.[42] During periods of higher than normal rainfall, however, agave seedlings and mature plants may revert to diurnal carbon fixation, temporarily reversing the process to favor the production of biomass over the conservation of plant moisture.

Natural processes of selection, adaptation, and species variation intersected with cultural practices of selection, differential use, and transplanting of agaves by different groups of indigenous peoples. Ethnographic and agro-ecological studies of the O'odham, Maricopa, Yavapai, and Apache peoples that traversed the Sonoran and western Chihuahuan deserts recorded the importance of gathered plants for their sustenance. Identified as mescal, different kinds of agaves figured among the foods and fibers gathered from saguaro, mesquite, pitahaya, and prickly pear during different seasons of the year and, especially, in times of drought, as was noted in the O'odham calendar sticks that recalled periods set aside for gathering mescal.[43] At the same time indigenous testimonies and observations by non-Indian travelers, governmental agents, and scholars did not make a hard and fast

distinction between food gathering and crop production, even among the Akimel O'odham of the northern Sonoran river valleys who, in good years, raised impressive harvests of maize, gourds, squashes, beans, cotton, and—after European contact—wheat. Each of these productive activities constituted a link in the spatial and temporal patterns that marked the climatic cycles and material cultures of the desert peoples who shaped the plains, river valleys, and upland monte of northern Mexico.

Documenting Encounters in Gran Chichimeca

Let us turn to archaeological, historical, and ethnographic records to trace the presence of agave in the histories of contact among different indigenous and Iberian groups of actors. The Hohokam settlements of the northern Sonoran Desert developed technologies for water management to cultivate agaves.[44] *Hohokam* (from the O'odham language, meaning "those who have finished") identifies a cultural complex of urban sites and irrigation canals throughout the greater Gila, Salt, and Santa Cruz drainages, which flourished and waned over a century before European contact.[45] Research conducted in the Santa Cruz River drainage northwest of Tucson, Arizona, identified two species—*Agave murpheyi* F. Gibson and *Agave parryi* Engelm—in close association with structures and artifacts related to the cultivation and harvesting of agave plants for fiber and food. Rock piles associated with roasting pits yielded burned remains of agave and stone mescal knives. These rock pile fields on the valley slopes above the floodplain show the remains of terraces and check dams as well as rounded rock mounds. Located advantageously to receive rainwater runoff, the heaped rocks and pebbles created uneven porous surfaces that allowed the infiltration of rainwater and reduced evaporation, enhancing soil moisture. Subsequent experiments have shown that root biomass and the number of leaves per plant increased among agaves planted in prehistoric rock pile fields and, moreover, that the rock piles helped protect these plants from rodent damage to leaves and roots.[46]

Archaeological surveys, selected site excavations, and experimental plantings support hypotheses that agave cultivation in rock pile fields supplied significant quantities of fibers and juice for consumption and weaving. These technologies allowed whole communities to harvest rainwater in the desert, enhance the moisture environment on exposed lower slopes, and cultivate certain species of agave for nutrition and handicraft industries. The extension of rock pile fields, covering more than 5 square kilometers, helps explain population growth and the florescence of Hohokam urban settlements because cultivating agaves complemented harvested crops and gathered fruits and seeds from desert and riparian resources.[47]

Located in the drainage of the Magdalena-Concepción rivers, the Cerro de Trincheras exemplifies the *trincheras* tradition of northern Sonora, so named because of characteristic ceramics and the stone terraces that ring hillsides, producing spaces for walls and rooms. The chronological range of this tradition extends from perhaps a few centuries BCE to 1450 CE; Cerro de Trincheras, the largest known site of this cultural formation, corresponds to a later phase (1300–1450 CE). Archaeologists have attributed these trincheras to defense, settlement, and agricultural surfaces; recent research suggests strongly that the terraces were not solely for defense but rather were built to support house sites, ceremonial centers, and cultivation. In addition to corn, squash, and cotton, the people of Cerro de Trincheras raised agave on contour terraces similar to the ones identified at the Hohokam sites of southern Arizona. Wild agave grows at higher altitudes, and the archaeologists Randy McGuire and Elisa Villalpando speculate that it may have been gathered and transplanted in the town of Cerro de Trincheras.[48] Although these techniques for cultivating agaves did not persist into the historic period, modern ethnographies have shown that the O'odham (Papago) and Cunca'ac (Seris) of the Sonoran Desert transplant local species of agaves.[49] The technique involves nurturance and redistribution of plant specimens, and we may surmise that some of these transplants descended from the species that took root under Hohokam and Trincheras cultivation.

Three pre-Hispanic sites on the western edge of the Chihuahuan Desert yield evidence of mixed foraging and agricultural subsistence strategies. The oldest of these, Cerro Juanaqueña, dating from 1300 to 1100 BCE, is the first known agricultural settlement in northwestern Mexico. El Zurdo, a small agricultural settlement, was occupied discontinuously from 700 to 1400 CE. Paquimé, the largest agricultural and urban settlement of northern Mexico, developed from the first millennium CE until 1450 CE, roughly parallel to the Hohokam settlements of the northern Sonoran Desert. Its agricultural base rested on maize, amaranth, beans, squash, gourds, cotton, and agave.[50] Archaeological excavations in the region of San Luis Potosí, in northeastern Mexico, have established the depth of hunter-gatherer cultures that lived from the fruits of the thorn forest, noting *A. lechuguilla* among the principal plants found in the region.[51]

The *Relación* by Álvar Núñez Cabeza de Vaca constitutes the first European chronicle to describe the lands and their inhabitants north of the Sierra Madre Oriental.[52] Cabeza de Vaca and his three companions endured seven years (1528–35) in "deserts and deserted lands," enslaved by different nomadic tribes, until they found the "trail of maize" at the confluence of the Conchos and Grande rivers, leading them through the Sierra Madre Occidental to the agricultural villages of northwestern Mexico.[53] He and his companions survived by digging for roots, fishing, and following their captors to the stands of

prickly pears (*Opuntia* spp.) whose fruit ripened in the late summer or early fall. They moved from tribe to tribe by becoming peddlers and medicine men, with a growing following of men, women, and children. Although the *Relación* does not mention agaves or mescal, Cabeza de Vaca reported eating the fruit and the roasted leaves of the *Opuntia* cacti as well as digging in the ground beneath the plants to extract their juices. The roasted leaves that calmed his hunger and the juices that quenched his thirst may have come from wild agave stands.[54] Following Cabeza de Vaca's journey, Spanish explorers began to penetrate the highland valley of Topia, a region of geographic and climatic ecotones between the tropical canyons and the highland desert that supported rainfall agriculture, where cultigens were mixed with gathered plants like the agave, *zapote*, prickly pear, and *guamuchil*. Chroniclers of the Francisco de Ibarra expedition (1564–65) reported seeing cloth woven from maguey fibers (pita) and agave leaves chewed and then turned into wine.[55]

The mid-sixteenth century marked a transition from Spanish explorations to the initial stages of mining, ranching, and missionary evangelization. Spanish settlements in Zacatecas, Durango, and Santa Bárbara—to name only three mining centers—set in motion networks of labor recruitment and provoked armed encounters that reverberated across the Gran Chichimeca. Mining, with large-scale excavation, timber consumption, mercury amalgamation, and ranching, initiated revolutionary environmental changes throughout northern New Spain.[56] At the same time, these colonial outposts led to the governance of Nueva Galicia and Nueva Vizcaya, producing regular streams of correspondence with more precise descriptions of locations and peoples than in the early chronicles.

The arrival of the Society of Jesus (Jesuits) to the Villa de Sinaloa, in 1591, opened avenues of access—however fraught with conflict—into piedmont valleys, sierras, and deserts that had remained marginal or autonomous in the uneven process of imperial expansion northward from Mesoamerica. Andrés Pérez de Ribas's *Historia de los triunfos de nuestra santa fé* (1645) combined his firsthand accounts of service in the missions of Sinaloa with a synthesis of reports from his fellow missionaries in both northwestern and northeastern New Spain. Pérez de Ribas contrasted the arid lands surrounding the Laguna de Parras and the Bolsón de Mapimí in Nueva Vizcaya with the missions he had helped to found in the piedmont valleys of the Sierra Madre Occidental: the forested hillsides and arable floodplains with relatively dense settlements of Sinaloa and Sonora seemed copious in comparison with the arid trails leading from Zacatecas or Guadiana to Parras.[57]

In 1594, the first two Jesuits entered this region, establishing their first mission on the shores of the Laguna de San Pedro, a small lake fed by the Nasas River. Four years later they moved the mission to a spring-fed site and named it Parras for a cane-like plant that grew on

the shores of the lake, reminding them of the vineyards of Spain, which were later transplanted to the Parras mission.[58] The Jesuits anticipated a rich spiritual harvest among the numerous *rancherías* that surrounded the laguna, noting the agricultural resources that could sustain a mission. Beyond this riparian environment, however, their pervasive impression of this region remained its aridity.

Travel was difficult through its desert basins in the absence of water along the trails. During the Jesuits' incursions into the mountainous communities of *quavilas* (Coahuila), several days' journey from the lake, native peoples taught the Jesuits to drink the "juice of wild plants that they call *mescales*, to which they are accustomed." Pérez de Ribas noted their useful substitution for sources of fresh water; he recognized mescal because he had seen it planted in the upper Río Mayo valley of Sinaloa in northwestern New Spain.[59]

Ethnography brings references to agaves into recent historical periods. The Tepehuanes occupied different ecological zones in the Sierra Madre Occidental and the high desert plains in what today corresponds to portions of Chihuahua, Durango, Nayarit, and Jalisco. Their name was interpreted as *tepetl* plus *hua*, to mean "people of the mountains," but different bands designated by the Spaniards as "tepehuanes del desierto" or "salineros" may have extended as far eastward as the Laguna de Parras and the Bolsón de Mapimí. Their languages are related to the great *tepima* chain of the Uto-Aztecan linguistic trunk. Present-day tepehuán speakers refer to themselves as *ódami* ("people"), a word resembling the *o'odham* of northern Sonora. Following Spanish contact, the Tepehuán were drawn into labor drafts for the mines and into the Jesuit missions of Nueva Vizcaya; the Salineros delivered salt to the mining *reale*s under the obligations of *encomienda*.[60] Multiple pressures of labor exploitation, dislocation, and disease sparked a regionwide rebellion in 1616–18; although some Tepehuanes returned to the missions, the rebellion opened new phases of migration and semi-sedentary lifeways that increasingly depended on hunting and gathering for survival.[61]

Campbell Pennington's extensive fieldwork among the Tepehuanes of Chihuahua in the mid-twentieth century distinguished two main ecological zones: the rolling uplands, characterized by temperate forests, and the canyon slopes, with thorn forests, cacti, yuccas, and agaves. In Tepehuán material culture, agaves provide intoxicating beverages, stupefying substances to aid in fishing, and food for humans. Four species yield the basic substance to make fermented drinks: the *ájurai* (*čawé*), maguey or mescal (*mái*), mescalillo (*guvúkai*), and lechuguilla (*jápari*). Their roots become a portable foodstuff when pit-fired for several days, then dried and stored. Tepehuanes weave agave fibers into their carrying baskets, and three species found on the rocky slopes of canyons yield a toxic substance for fishing when the leaves are crushed and thrown into a fish-bearing stream.[62]

On the western slopes of the Sierra Madre Occidental, Pennington carried out parallel research among the peoples known to the Spaniards as Pima or Nebome (*O'odham*). Like the Tepehuanes, the O'odham distinguish among different species of agaves for producing fermented beverages, starchy food cakes, fiber, and medicines, and as toxins for stupefying fish. The O'odham process the hearts of the *Agave yaquiana* (mescal, maguey, or *su'ut*) and of the *Agave bovicornuta* (lechuguilla) for distilling a regional mescal called *bacanora*. Both the roots and hearts of these agaves are cooked and pounded into a storable food source. Sap excreted from the leaves of the lechuguilla helps to heal wounds; ixtle fibers were woven into carrying baskets in the mountainous Pima country from the mission era until the mid-twentieth century.[63] Research among the *Rarámuri* (Tarahumara) confirms the utility of agaves for mountainous peoples whose modes of livelihood combine farming, hunting, fishing, and gathering, and it highlights the religious and curative properties ascribed to certain kinds of agaves.[64] Western Rarámuri transplant two species of agave from woodlands and slopes and cultivate them near their house gardens: *A. americana* L. var. *expansa* and *A. pacifica,* the latter known among Mexicans as "mescal del monte" (wild) and "mescal casero" (cultivated). The hearts of the cultivated variety are larger than those of the wild plants, enriching the food cakes made from the pit-baked hearts, the tortillas ground from the flowers, and the taste of their fermented drink.

Agaves serve the Rarámuri principally as food, particularly before the summer rains bring moisture to planted crops and wild greens sprout on the slopes of the Sierra Madre Occidental. Like the Tepehuán, O'odham, and Opata, the Rarámuri process agave hearts and leaf bases by pit baking to produce edible and storable "mescal bread." In addition, the leaves provide fiber for weaving, soap, and stupefying toxins for fishing; the stalks provide edible flowers, and the juices serve to produce alcoholic beverages, including *suguí*, which when mixed with fermented maize enhances the *tesgüino* that is central to Rarámuri religious ceremonies. The Rarámuri incorporate the *A. shrevei* in rituals for curing, fertility, and death. Agave hearts soaked in water embody the healing power of God through nature, to protect the healthy and restore sick persons to health. When death occurs, however, agave water preserves the corpse before burial, eases the deceased person's separation from the community, and protects the living from the dead.[65]

Conclusions

The children of Mayahuel are the vegetative offshoots of the mature plants that emerge from the base of their stems, spreading the distribution of different species of agaves. Just as significantly, her sons and

daughters are the gatherers and cultivators that transplant agave offshoots, extract fibers from their leaves, drink the aguamiel, turn it into pulque and mescal, and roast the leaves, hearts, and roots of the plants for nourishment. The multilayered symbolism surrounding the transformation of Mayahuel into the maguey plant highlights the cultural innovations of fermentation, weaving, curing, food processing, and storage. Spanning religion and science, the belief systems and the organization of knowledge focused on agaves follow multiple streams. One of these begins with Nahua scribes and doctors, extends to early modern European treatises, and converges in modern theories of human ecology. A parallel route descends from the Hohokam and Paquimé town builders of the Sonoran and Chihuahuan deserts to the agricultural and hunter-gatherer peoples who developed their own nomenclatures for distinguishing among different varieties of agaves. The phylogenetic and life-form systems of classification used by modern scholars rest on a solid foundation of empirical studies and conceptual frameworks originating in different approaches to natural history.

Linking the production of space to the interplay of life-forms and environmental adaptations illustrates the constellation of cultural and natural forces that shape desert environments. To be sure, desert landscapes are contingent on precipitation, soil quality, altitude, stream flow, and landforms. Nonetheless, human technique alters the environment in the course of appropriating resources, establishing temporary settlements, harvesting water, and transplanting movable gardens. The Agaveae family illustrates these principles with particular relevancy for the ecotones and cultural interstices between Mesoamerica and the Gran Chichimeca. Like other succulent life-forms, agaves have filled the ecological niches created by the basin-and-range topography that traverses the northern deserts in radiating arteries. Their adaptive strategies exhibited through moisture conservation, slow production of biomass, and alternative means of reproduction through seeding and vegetative offshoots merged with the needs and cultural preferences of different farming and gathering peoples in the creation of desert landscapes.

The materials assembled here tend to affirm the sufficiency of agaves to meet basic human needs for pre-Hispanic cultural formations, colonial encounters, and ethnographic observations of living communities. Humans select and process different parts of the agave plant to produce food, aguamiel and mescal, medicines and poisons, fibers for cloth and carrying baskets, and pencas for building and roofing. From fleeting references to maguey or mescal in the early chronicles of exploration and conquest, the reports of colonial missionaries, and recent ethnographic studies, what emerges is the close association of agaves and specific human communities.

These clusters of relationships are both creative and destructive. Indigenous and mestizo connoisseurs of distilled mescal rely on wild stands of agaves to produce the drink, and their practices of uprooting entire plants or cutting out the base of the rosette before the stalk finishes blooming disrupts the reproductive symbiosis between agaves and bats.[66] The population densities and varieties of agave stands are often diminished by increasing herds of free-ranging livestock, the extension of paved highways, new mining discoveries, and urban settlements. In central and southern Mexico, although this is beyond the scope of the present study, agave monocultures for the production of pulque, mescal, tequila, rope, and twine have undoubtedly altered the genetic composition of these species.[67] Over millennia, however, the children of Mayahuel have helped to propagate nearly two hundred taxa of agaves. Their nurturance of agaves through gathering, transplanting, and processing has shaped desert landscapes in ways that are *both* historical and ecological, creating cosmologies and systems of knowledge through the production of space and their cultural representations of arid lands.

The production of space, as conceptualized by Henri Lefebvre, helps us to articulate the *longue durée* of human–agave symbiosis. Transplanting selected species and varieties of agave from the open range or desert scrub to domestic sites close to cultivated fields and dwellings characterizes the cultures of agave among numerous indigenous peoples. Cultivation of the "mescal casero" not only produces more biomass for agave cakes than gathering the "mescal de monte," it also marks domestic space in villages and *rancherías*. In both northern Mexico and Mesoamerica, transplanted agaves establish fences around house lots and cornfields; like the transplanted thorny branches of the *ocotillo* used in rural Sonora to enclose living quarters and gardens, planted agaves with their spiny pencas connote protection and a sense of property, distinguishing between internal familiar spaces and external woodlands or grasslands for communal use or the monte associated with hunting and gathering.

The historical dimension of agaves in the evolution of desert landscapes becomes clearer through the conceptual framework of life-forms. In the monte, people have both nurtured and endangered agave ecotones through vegetative reproduction and indiscriminate harvesting. The ecological revolutions set in motion by colonial settlements through the concentration of indigenous peoples in mission towns, the deforestation unleashed by mining, and the growth of European crops and livestock circumscribed and changed the habitats for wildlife and altered long-standing patterns of seasonal hunting and gathering. As forests and grasslands receded, new ecological niches may have opened for life-forms best adapted to arid lands, like the *A. lechuguilla* and the cluster of succulent species within the subgenus

Deserticolae. Indigenous peoples and other rural folk—native or migrants to the region—adapted their foraging techniques to these new circumstances, and the wide variety and distribution of agaves may have helped them to survive.

The religious connotations that surround agaves in both Mesoamerica and the northern Chichimeca constitute a kind of representational space alluding to the "shining desert" and to the liminality of human experience in nature, between cultivation and gathering, and between life and death. Mayahuel figures as a powerful symbol of fertility and creativity. Part goddess and part plant, Mayahuel together with Pahtecatl provides the source of fermented pulque and, through her birthing of Centeotl, she may be considered a progenitor for the cultivation of maize, the centerpiece of Mesoamerican agriculture. The spiritual power of fermentation arising from agaves is replicated strikingly among the Rarámuri when they mix suguí and tesgüino from agaves and maize for their ceremonial drinking. Agave liquor brings the Rarámuri closer to God, and, with equal significance, agave water carries people through illness and death. These two temporal and spatial nodes of our story, centered on agaves, show how nature and culture intertwine in the production of space and in the environmental history of evolving desert landscapes.

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Notes

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1 Henri Lefebvre, *The Production of Space*, trans. D. Nicholson-Smith (Oxford: Basil-Blackwell, 1991).

2 Lefebvre, *The Production of Space*; Christian Schmid, "Henri Lefebvre's Theory of the Production of Space. Towards a Three-Dimensional Dialectic," in *Space,*

Difference, Everyday Life. Reading Henri Lefebvre, ed. B. Goonewardena et al. (New York: Routledge, 2008), 27–45.

3 Frank S. Crosswhite and Carol D. Crosswhite, "A Classification of Life Forms of the Sonoran Desert, with Emphasis on the Seed Plants and Their Survival Strategies," *Desert Plants* 5, no. 4 (1984): 131–61. *Biome:* A biological subdivision of the earth's surface that reflects the ecological and physiognomic character of the vegetation. Michael Allaby, ed., *A Dictionary of Plant Sciences* (Oxford University Press, 2006). *Oxford Reference Online*, http://www.oxfordreference.com.

4 Crosswhite and Crosswhite, "A Classification of Life Forms," 134.

5 Gordon L. Bender, ed., *Reference Handbook on the Deserts of North America* (Westport: Greenwood Press, 1982); W. G. McGinnies, "What Is a Desert?" *Desert Plants* 6, no. 4 (1985): 182; Forrest Shreve and Ira L. Wiggins, *Vegetation and Flora of the Sonoran Desert*. 2 vols. (Stanford: Stanford University Press, 1964): 1, 26; William E. Doolittle, "Introduction," in H. Aschmann, *The Evolving Landscape. Homer Aschmann's Geography*, ed. Martin J. Pasqualetti (Baltimore: Johns Hopkins University Press, 1997), 227.

6 Bernard L. Fontana, *Of Earth and Little Rain. The Papago Indians* (Flagstaff: Northland Press, 1981); Gary Paul Nabhan, *The Desert Smells Like Rain. A Naturalist in Papago Indian Country* (San Francisco: North Point Press, 1982), and *Cultures of Habitat. On Nature, Culture, and Story* (Washington, DC: Counterpoint, 1997); see also José Luis Mirafuentes, Elisa Villalpando, and Jaime Nieto Ramírez, "El mezquite, sus usos culinarios," in *Nómadas y sedentarios en el Norte de México. Homenaje a Beatriz Braniff*, ed. Marie-Areti Hers, José Luis Mirafuentes, María de los Dolores Soto, and Miguel Vallebueno (México: Universidad Nacional Autónoma de México, 2000): 715–18. Cholla is *Opuntia bigelovii*; mesquite is *Prosopis juliflora*; saguaro is *Carnegiea gigantea*.

7 Fontana, *Of Earth and Little Rain*; Gary Paul Nabhan, "*Ak-ciñ* and the Environment of Papago Indian Fields," *Applied Geography* 6, no. 1 (1986): 61–76.

8 Doolittle, "Introduction," 227–31; Aschmann, *The Evolving Landscape*, 232. The chronicled expeditions follow in this order: Nuño and Diego de Guzmán (1530–33), Alvar Núñez Cabeza de Vaca (1528–37), Fray Marcos de Niza (1539), Francisco Vázquez de Coronado and Hernando de Soto (1540–42), and Francisco de Ibarra (1564–65).

9 Carl O. Sauer, *The Road to Cíbola* (Berkeley: University of California Press, 1932), Ibero-Americana 3: 7–16.

10 James Scott, *Seeing Like a State, How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998): 311–28. I use technique here in the sense that Scott develops his definition of *mētis* as local practical knowledge; see also Lefebvre, *The Production of Space*.

11 Howard Scott Gentry, *Agaves of Continental North America* (Tucson: University of Arizona Press, 1982): 30–46; C. Edward Freeman and William H. Reid, "Aspects of the Reproductive Biology of Agave lechuguilla Torr.," *Desert Plants* 7, no. 2 (1985): 75–80; Gary Paul Nabhan, *Gathering the Desert*, illus. Paul Mirocha (Tucson: University of Arizona Press, 1985), 40–43.

12 Gentry, *Agaves of Continental North America*, 4–8.

13 Ibid., 6.

14 Nahuatl, one of the principal languages of central Mexico, developed oral traditions and pictographic written codices for ritual calendars, historical

legends, and tribute counts for the Aztec empire. Arguably, the use of Nahuatl spread even further after Spanish contact when the language was converted to a Latin alphabet and it became the colonial lingua franca.

15 See Beatriz C. Braniff et al., *La gran chichimeca. El lugar de las rocas secas* (México: CONACULTA; Milan: Editoriale Jaca Book SpA, 2000); Joseph Arlegui, *Chronica de la Provincia de N.S.P.S. Francisco de Zacatecas* (México: Joseph Bernardo de Hogal, 1737); Jose Joaquin Granados y Gálvez, *Tardes americanas: gobierno gentil y católico: breve y particular noticia de toda la historia indiana* (México: Imprenta Matritense de D. Felipe de Zúñiga y Ontiveros, 1778). *Chichimeca*, a term that filtered into early Spanish chronicles from Nahuatl codices and oral traditions, referred to the "barbarian" hunter-gatherers (often distinguished pictorially by their use of bows and arrows) associated with the arid lands north of Mesoamerica. Paradoxically, the proud Mexicans who would build the great Aztec capital of Tenochtitlan traced their ancestry to the Chichimec migratory tribes of northern Mexico.

16 On Proto-Uto-Aztecan migrations and their implications for both farming and gathering practices, see William L. Merrill and Celia López González, "Humans and Other Mammals in Prehispanic Chihuahua," in *Human and Faunal Relationships Reviewed: An Archaeozoological Approach*, ed. Eduardo Corona Martínez and Joaquín Arroyo-Cabrales (British Archaeological Reports International Series No.1627. Oxford: Archaeopress, 2007), 43–62; William L. Merrill, Robert J. Hard, Jonathan B. Mabry, Gayle Fritz, Karen R. Adams, John R. Roney, and A. C. MacWilliams, "The Diffusion of Maize to the Southwestern United States and Its Impact," *Proceedings of the National Academy of Sciences* 106, no. 50 (2009): 21019–26, 1–4.

17 Compare the images of Mayahuel in the Códex Borbónico, the Códice Nuttall, and the Códex Fejérváry-Mayer, in Oswaldo Gonçalves de Lima, *El maguey y el pulque en los códices mexicanos* (México, D.F.: Fondo de Cultura Económica, 1956); the reproduction of the rendering of Mayahuel in the Códex Borbónico appears in Gentry, *Agaves of Continental North America*, 9.

18 Eloise Quiñones Keber, *Codex Telleriano-Remensis. Ritual, Divination, and History in a Pictorial Aztec Manuscript* (Austin: University of Texas Press, 1995): folios 14r, 15v, pp. 160, 174, 177, 262. The folio that would have portrayed Mayahuel in this codex is missing.

19 Gentry, *Agaves of Continental North America*, 8–16; Gonçalves de Lima, *El maguey*.

20 José M. López Piñero and José Pardo Tomás, "The Contribution of Hernández to European Botany and Materia Medica," in *Searching for the Secrets of Nature. The Life and Works of Dr. Francisco Hernández*, ed. Simón Varey, Rafael Chabrán, and Dora B. Weiner (Stanford: Stanford University Press, 2000), 122–37.

21 Varey et al., *Mexican Treasury*, 53; Antonio Barrera-Osorio, "Knowledge and Empiricism in the Sixteenth-Century Spanish Atlantic World," in *Science in the Spanish and Portuguese Empires, 1500–1800*, ed. D. Bleichmar, P. De Vos, K. Huffine, and K. Sheehan (Stanford: Stanford University Press, 2009), 231–32; Jorge Cañizares-Esguerra, *Nature, Empire, and Nation. Explorations of the History of Science in the Iberian World* (Stanford: Stanford University Press, 2006), 28–31.

22 Francisco Ximénez, *Quatro Libros de la Naturaleza y virtudes de las plantas, y animales que están recevidos en el uso de Medicina en la Nueva España* (México: Davalos, 1615). Spaniards first learned the word *maguey*, the preferred

translation for *metl*, in Hispaniola, and they brought the term with them to New Spain to describe both wild and planted stands of agaves.

23 Ximénez (Hernández), *Quatro Libros*, 147: "Siembranse los pimpollos, o renuevos, que nacen cerca de la planta principal."

24 Ibid., 147–50.

25 Nardo Antonio Recchо and Francisco Hernández, *Rerum medicarum novae hispaniae thesaurus seu plantarum animalium mineralium mexicanorum. Historia ex-Francisci Hernández Novi Orbis Medici Primarii relationibus in ipsa MEXICANA urbe conscriptis a Nardo Antonio Reccho, Monte Coruinate Cath. Maiest. Medico et Neap. Regni Archiatro Generali Iuissu Philippi II. Hisp. Ind. Etc. Regis Collecta ac in ordenem digesta a JOANNE TERRENTIO LYNCEO Constantiense Germº Pho ac Medico Notis Illustrata* (Rome: Typographeio Vitalis Mascardi, 1651).

26 Schulze Johannes Henricus, *Dissertatio Historio-Medica de Aloe* (Piso Anno Academiae Saeculari A.D. IVNII, 1723), 10–11; F. Ruysch, *Adversariorum anatomico-medico-chirurgicorum Decas Tertia* (Amsterdam: Janssonio-Waesbergios, 1733), 11–12.

27 I thank Miguel Tamen for pointing this out to me. On the "objectivization" of nature through science, see Carolyn Merchant, *The Death of Nature. Women, Ecology, and the Scientific Revolution* (San Francisco: HarperCollins, 1980; repr., 1989), 164–252.

28 Linnaeus, 1753, cited in Gentry, *Agaves of Continental North America*, 27–29.

29 Gentry, *Agaves of Continental North America*, xi–xii, 49–58.

30 For example, the Desert Botanical Garden (Phoenix, AZ), the Escuela Nacional de Ciencias Biológicas (Mexico City), Missouri [Henry Shaw] Botanical Garden (St. Louis, MO), and Huntington Botanical Gardens (San Marino, CA).

31 Mexican botanist Jerzy Rzedowski compiled a comprehensive summary of vegetation biomes as well as specific plant communities and genera, including agaves, in Rzedowski, *Vegetación de México* (México: Editorial Limusa, con la parte correspondiente a la vegetación litoral marina a cargo de Laura Huerta M., 1981). See also Robert Bye and the work of the UNAM Botanical Garden with the Rarámuri in the Chihuahuan Desert and Sierra Madre Occidental in Robert A. Bye, Don Burgess, and Albino Mares Trías, "Ethnobotany of the Western Tarahumara of Chihuahua, Mexico. 1. Notes on the Genus *Agave*," *Botanical Museum Leaflets* 24: 85–112 (Cambridge: Harvard University, 1975).

32 Gentry, *Agaves of Continental North America*, 49; Howard Scott Gentry, *The Agave Family in Sonora* (Washington, DC: U.S. Department of Agriculture, Agriculture Handbook 399, 1972): 42–150.

33 Gentry, *Agaves of Continental North America*, 1982: 124–57; Freeman and Reid, "Aspects of the Reproductive Biology," 75.

34 Gentry, *Agaves of Continental North America*, 354–415.

35 Ibid., 416–64; Gentry, *The Agave Family in Sonora*, 101–19. In his 1972 monograph, dedicated to Sonora, Gentry provided local names for species and varieties, and he listed detailed instances of local uses. One of the Apache bands whose territory spanned northeastern Coahuila and western Texas, for example, was identified in colonial sources as "Apaches Mescales." See Diana Hadley, Thomas H. Naylor, and Mardith K. Schuetz-Miller, eds. *The Presidio and Militia on the Northern Frontier of New Spain*, vol. 2, *The Central Corridor and*

the Texas Corridor, 1700–1765 (Tucson: University of Arizona Press, 1997), 388, 391.

36 D. T. MacDougal, "Some Aspects of Desert Vegetation," *Plant World* 6 (1903): 249–57.

37 Forrest Shreve, "The Desert Vegetation of North America," *Botanical Review* 8 (1942): 195–246, and *Vegetation of the Sonoran Desert* (Washington, DC: Carnegie Institution of Washington, 1951); Shreve and Wiggins, *Vegetation and Flora of the Sonoran Desert*.

38 Crosswhite and Crosswhite, "A Classification of Life Forms," 135.

39 Carl O. Sauer, *Agricultural Origins and Dispersals*. Bowman Memorial Lectures (New York: American Geographical Society, 1952), 11–12, and "Cultural Factors in Plant Domestication in the New World," *Euphytica* 14 (1965): 301–6, cited in Gentry, *Agaves of Continental North America*, 4.

40 Aschmann, *The Evolving Landscape*, 50, 244.

41 Ibid., 317, 325.

42 Defined as crassulacean acid metabolism (CAM), this method of carbon dioxide fixation conserves water in certain succulent, drought-resistant plants. Michael Allaby, ed., *Dictionary of Plant Sciences*. See Crosswhite and Crosswhite, "A Classification of Life Forms," 140; Bye, Burgess, and Trías, "Ethnobotany of the Western Tarahumara," 39.

43 Robert A. Hackenberg, *Pima-Maricopa Indians. Aboriginal Land Use and Occupancy of the Pima-Maricopa Indians*. 2 vols. (New York: Garland, 1974), 1: 53–55, 67–68, citing Edward W. Gifford, "The Southeastern Yavapai," *University of California Publications in American Archaeology and Ethnology* 29, no. 3 (Berkeley: University of California Press, 1932); Gifford, "Northeastern and Western Yavapai," *University of California Publications in American Archaeology and Ethnology* 34, no. 4 (Berkeley: University of California Press, 1936); Hackenburg 2: 89–93, citing Edward F. Castetter and Willis H. Bell, *Pima and Papago Indian Agriculture* (Albuquerque: University of New Mexico Press, 1942), and Frank Russell, *The Pima Indians* (Washington, DC: Smithsonian Institution Bureau of American Ethnology 1904–5; U.S. Government Printing Office, 1908).

44 Suzanne K. Fish, Paul R. Fish, Charles Miksicek, and John Madsen, "Prehistoric Agave Cultivation in Southern Arizona," *Desert Plants* 7, no. 2 (1985): 107–12, 100; Henry D. Wallace, Paul R. Fish, and Suzanne K. Fish, "Tumamoc Hill and the Early Pioneer Period Occupation of the Tucson Basin," in *Trincheras Sites in Time, Space, and Society*, ed. Suzanne K. Fish, Paul R. Rish, and M. Elisa Villalpando (Tucson: University of Arizona Press, 2007), 71.

45 David Leedom Shaul and Jane H. Hill, "Tepimans, Yumans, and Other Hohokam," *American Antiquity* 63, no. 3 (1998): 375–77. The longest periodization ascribed to the Hohokam cultural complex extends for more than a millennium from 300 BCE to 1100 CE; more conservative estimates place the development and decline of the first Hohokam center (in Snaketown, Arizona) between 500 and 1175 CE and calculate the second phase of Hohokam cultural development between 1100 and 1450 CE. See Braniff et al., *La gran chichimeca*, 133–35; Emil W. Haury, *The Hohokam: Desert Farmers and Craftsmen; Excavations at Snaketown, 1964–1965* (Tucson: University of Arizona Press, 1976); Randall H. McGuire and Michael B. Schiffer, eds., *Hohokam and Patayan Prehistory of Southwestern Arizona* (New York: Academic Press, 1982); Karen G. Harry,

"Examining the Northern Tucson Basin Regional System. Recent Evidence from the Marana and Los Robles Communities," in *Boundaries and Territories: Prehistory of the U.S. Southwest and Northern Mexico*, ed. M. Elisa Villalpando (Tempe: Arizona State University Press, Anthropological Research Papers 54, 2002), 83–94, esp. 89; María Elisa Villalpando, "The Archaeological Traditions of Sonora," in *Greater Mesoamerica. The Archaeology of West and Northwest Mexico*, ed. Michael S. Foster and Shirley Gorenstein (Salt Lake City: University of Utah Press, 2000), 241–54, esp. 243.

46 Fish et al., "Tumamoc Hill," 107–10.

47 Ibid., 110–12; Michael F. Logan, *The Lessening Stream. An Environmental History of the Santa Cruz River* (Tucson: University of Arizona Press, 2002), 31–33.

48 Randall H. McGuire and M. Elisa Villalpando, "Excavations at Cerro de Trincheras," in *Trincheras Sites in Time, Space, and Society*, ed. Suzanne K. Fish, Paul R. Fish, and M. Elisa Villalpando (Tucson: University of Arizona Press, 2007), 137–64; Carl O. Sauer and Donald Brand, *Prehistoric Settlements of Sonora, with Special Reference to Cerros de Trincheras*, in University of California Publications in Geography 5(3): 67–148, plates 7–18, figures in text (Berkeley: University of California Press), 1931.

49 Sauer and Brand, *Prehistoric Settlements of Sonora*, 109; Gentry, *Agaves of Continental North America*,: 442–43; Richard S. Felger and Mary B. Moser, *People of the Desert and Sea* (Tucson: University of Arizona Press, 1985).

50 Robert J. Hard and John R. Roney, "Cerros de Trincheras in Northwestern Chihuahua," in *Trincheras Sites in Time, Space, and Society*, ed. Suzanne K. Fish, Paul R. Fish, and M. Elisa Villalpando (Tucson: University of Arizona Press, 2007), 11–33; Merrill and López González, "Humans and Other Mammals in Prehispanic Chihuahua," 44–45.

51 Monika Tesch Knoch, "Aridoamérica y su frontera sur: aspectos arqueológicos dentro de la zona media potosina," in *Nómadas y sedentarios en el Norte de México. Homenaje a Beatriz Braniff*, ed. Marie-Areti Hers, José Luis Mirafuentes, María de los Dolores Soto, and Miguel Vallebueno (México: Universidad Nacional Autónoma de México, 2000), 547–50.

52 Rolena Adorno and Patrick Charles Pautz, eds., *Álvar Núñez Cabeza de Vaca. His Account, His Life, and the Expedition of Pánfilo de Narváez*. 3 vols. (Lincoln: University of Nebraska Press, 1999). Four survivors of Pánfilo de Narváez's failed expedition of 1527 traced a nine-year odyssey moving westward around the rim of the Gulf of Mexico. Cabeza de Vaca penned or dictated his *Relación* during his stay in the viceregal court of Mexico City in 1536. He recovered from memory the arduous adventures he and his companions endured in the Gran Chichimeca. The *Relación* was first published in Zamora in 1542; the second edition, together with the *Comentarios* on Cabeza de Vaca's later expedition to Río de la Plata, was published in Valladolid, 1555 (1: xvi).

53 Sauer, *The Road to Cíbola*, 14–16.

54 See Adorno and Pautz, *Álvar Núñez Cabeza de Vaca*, 1: 58–59, for "desiertos y despoblados"; 1: 129, 143, 149–51, 169 for *tunas*; 1: 171, 191 for mesquite as a source of food before the ripening of the prickly pears; 1: 175 for eating the roasted leaves of prickly pears.

55 Balthasar de Obregón, *Historia de los descubrimientos de Nueva España*, ed. Eva María Bravo (Seville: Ediciones Alfar, 1997 [1584]); Ralph L. Beals, *The Acaxee*.

A Mountain Tribe of Durango and Sinaloa (Berkeley: University of California Press, 1933, Ibero-Americana: 6), 5–9. Zapote (*Achras sapota*) and guamuchil (*Pithecellodium mexicanum* or *sonorae*) are both wild fruits obtained from shrubs or trees. Shreve and Wiggins, *Vegetation and Flora of the Sonoran Desert*, 1: 589, II: 1081. See note 8 on the major sixteenth-century expeditions through the northern arid lands in search of "new Mexicos."

56 Chantal Cramaussel, *Poblar la frontera. La provincia de Santa Bárbara en Nueva Vizcaya durante los siglos XVI y XVII* (Zamora, El Colegio de Michoacán, 2006); Robert C. West, *The Mining Community in Northern New Spain: the Parral Mining District* (Berkeley and Los Angeles: University of California Press, 1949, Ibero-Americana 30); Daviken Studnicki-Gizbert and David Schecter, "The Environmental Dynamics of a Colonial Fuel-Rush: Silver Mining and Deforestation in New Spain, 1522 to 1810," *Environmental History* 15 (2010): 94–119.

57 Andrés Pérez de Ribas, *Historia de los triunfos de nuestra santa fee entre gentes las más bárbaras, y fieras del nuevo Orbe* (Madrid: Alonso de Paredes, 1645). [*History of the Triumphs of our Holy Faith*, ed. and trans. Daniel Reff (Tucson: University of Arizona Press, 1999)], 11: 669. The Bolsón de Mapimí and the Parras Lagunera region span the modern states of Durango and Coahuila.

58 Ibid., 669–70, 671. See Shreve and Wiggins, *Vegetation and Flora of the Sonoran Desert*, I: 229. On the Mission of Santa Maria de Parras, see José Gabriel Martínez Serna, "Vineyards in the Desert: The Jesuits and the Rise and Decline of an Indian Town in New Spain's Northeastern Borderlands" (PhD diss., Southern Methodist University, 2009); Campbell W. Pennington, *The Tepehuan of Chihuahua. Their Material Culture* (Salt Lake City: University of Utah, 1969): 11–12.

59 Pérez de Ribas, *Historia de los triunfos de nuestra santa fee*, 11: 677, 681, 697; 3: 186–89.

60 Pennington, *The Tepehuan of Chihuahua*, 10–22; Chantal Cramaussel, "De cómo los españoles clasificaban a los indios. Naciones y encomiendas en la Nueva Vizcaya central," in *Nómadas y sedentarios en el Norte de México. Homenaje a Beatriz Braniff*, ed. Marie-Areti Hers, José Luis Mirafuentes, María de los Dolores Soto, and Miguel Vallebueno (México: Universidad Nacional Autónoma de México, 2000), 280–84; Leopoldo Valiñas Coalla, "Lo que la lingüística yutoazteca podría aportar en la reconstrucción histórica del Norte de México," in *Nómadas y sedentarios en el Norte de México. Homenaje a Beatriz Braniff*, ed. Marie-Areti Hers, José Luis Mirafuentes, María de los Dolores Soto, and Miguel Vallebueno (México: Universidad Nacional Autónoma de México, 2000), 181–85; Susan M. Deeds, "Cómo historiar con poca historia y menos arqueología: clasificación de los acaxées, xiximes, tepehuanes, tarahumaras y conchos," in *Nómadas y sedentarios en el Norte de México. Homenaje a Beatriz Braniff*, ed. Marie-Areti Hers, José Luis Mirafuentes, María de los Dolores Soto, and Miguel Vallebueno (México: Universidad Nacional Autónoma de México, 2000), 385–87.

61 Susan M. Deeds, "Indigenous Rebellions on the Northern Mexican Mission Frontier: From First-Generation to Later Colonial Responses," in *Contested Ground. Comparative Frontiers on the Northern and Southern Edges of the Spanish Empire*, ed. Donna J. Guy and Thomas E. Sheridan (Tucson: University of Arizona Press, 1998), 33; Susan M. Deeds, *Defiance and Deference in Mexico's Colonial North. Indians under Spanish Rule in Nueva Vizcaya* (Austin: University of Texas Press, 2003), 16–34.

62 Pennington, *The Tepehuan of Chihuahua*, 110, 133, 141, 195–197.

63 Campbell W. Pennington, *The Pima Bajo of Central Sonora, Mexico. The Material Culture*, vol. 1 (Salt Lake City: University of Utah Press, 1980), 186, 230–31, 266, 361–62, 367; Cynthia Radding, *Wandering Peoples. Colonialism, Ethnic Spaces, and Ecological Frontiers in Northwestern Mexico, 1700–1850* (Durham: Duke University Press, 1997), 55–57. Pennington cited the *Relaciones* of 1743 and 1744 by Felipe Ségesser, Jesuit missionary in Tecoripa. David A. Yetman, *The Ópatas. In search of a Sonoran People* (Tucson: University of Arizona Press, 2010), 22. Opata (*Tegüima*) villagers of the Sonoran piedmont, like the O'odham, roasted agave heads for food.

64 Bye, Burgess, and Trías, "Ethnobotany of the Western Tarahumara," 85–112; William L. Merrill, *Rarámuri Souls. Knowledge and Social Process in Northern Mexico* (Washington, DC: Smithsonian Institution Press, 1988), 121–51, 153–190.

65 Bye, Burgess, and Trías, "Ethnobotany of the Western Tarahumara," 91; Merrill, *Rarámuri Souls*, 125, 138–39, 143–49, 163–70.

66 Yetman, *The Ópatas*, 23; Nabhan, *Gathering the Desert*, 40–43.

67 Evans, Sterling. 2007. *Bound in Twine: The History and Ecology of the Henequen-Wheat Complex for Mexico and the American and Canadian Plains, 1880–1950*. (College Station, TX: TAMU Press), 14–20.

68 Mexoxoctli may be *Agave Salmiana* ssp. Crassispina, known in Mexico as "maguey verde." See Rafael Martínez-Morales and Susan E. Meyer, "A Demographic Study of Maguey Verde," *Desert Plants* 7, no. 2 (1985): 61–64, 101–2.