

# AZTEC DROUGHT AND THE “CURSE OF ONE RABBIT”

BY MATTHEW D. THERRELL, DAVID W. STAHL, AND RODOLFO ACUÑA SOTO

Aztec codices and tree-ring chronologies provide a new record of the occurrence and impacts of extreme drought in central Mexico, and corroborate Aztec climate folklore.

**T**he name “Aztec” has generally been applied to the people of central Mexico who shared a similar language, religion, and political system at the time of Spanish contact. They are exemplified by the Mexica who dominated the region from their capitol of Tenochtitlan (modern Mexico City), in a “triple alliance” with two other nearby city states, Texcoco and Tlacopan.

Prior to conquest, the Nahuatl-speaking Aztecs lacked an alphabetical writing system and documents were produced as pictorial “books” painted on skins or native amatl (bark) paper. Included among these documents were maps, tribute records, genealogies of ruling families, and *alteptl annals* that principally recorded the history of individual *alteptl* (i.e., city-states; Gibson 1964; Boone 2000).

Only about 10% of the 160 or so known natively produced manuscripts from Mexico are thought to be prehispanic, and none of the historical annals are considered to predate conquest (Bierhorst 1992;

Boone 2000). The Spanish destroyed most of the ancient manuscripts they called “codices” because of heretical or appalling content, such as descriptions of human sacrifice or cannibalism. Many others were simply lost to time. However, during the decades following conquest many historical annals and other codices were recreated both as pictorial copies of the originals and as written descriptions of what the original images portrayed. Some manuscripts were prepared exclusively for native Nahuatl readers, while others were commissioned by Spanish civil and religious entities, which accepted the painted manuscripts as valid historical records (Boone 2000).

The annals were primarily focused on religious and political events, such as conquests, but a variety of natural phenomena were also recorded. These include volcanic eruptions, earthquakes, solar eclipses, and anomalous climatic events such as storms and drought (Fig. 1). None of the Aztec historical documents cover the general history of the Aztec sphere of influence or even the Valley of Mexico (Dibble 1981). Because each of the *alteptl* annals are focused on historical events that impacted individual city-states, they serve as independent sources for major events such as drought. These major events were usually recorded by multiple sources (Dibble 1981). In the pictorial manuscripts, history is recorded as a continuum of year signs with portrayals of important events connected to the year sign (e.g., Fig. 1).

Although correlation between the Aztec and Western calendars suffers from problems such as the treat-

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ment of leap years and slight differences in the beginning of the annual cycle, the content and general temporal accuracy of the codices has been extensively studied and is largely confirmed by the cross-referencing of indisputable historic events recorded in multiple codices (e.g., Caso 1971; Dibble 1981; Quiñones Keber 1995; Boone 2000). The temporal accuracy of the codices, in the latter portion of the Aztec era, has been further confirmed by comparison of Aztec dates for celestial events such as solar eclipses with known astronomical chronologies (Aveni 1980).

We have examined most of the major historical annals from central Mexico for descriptions of

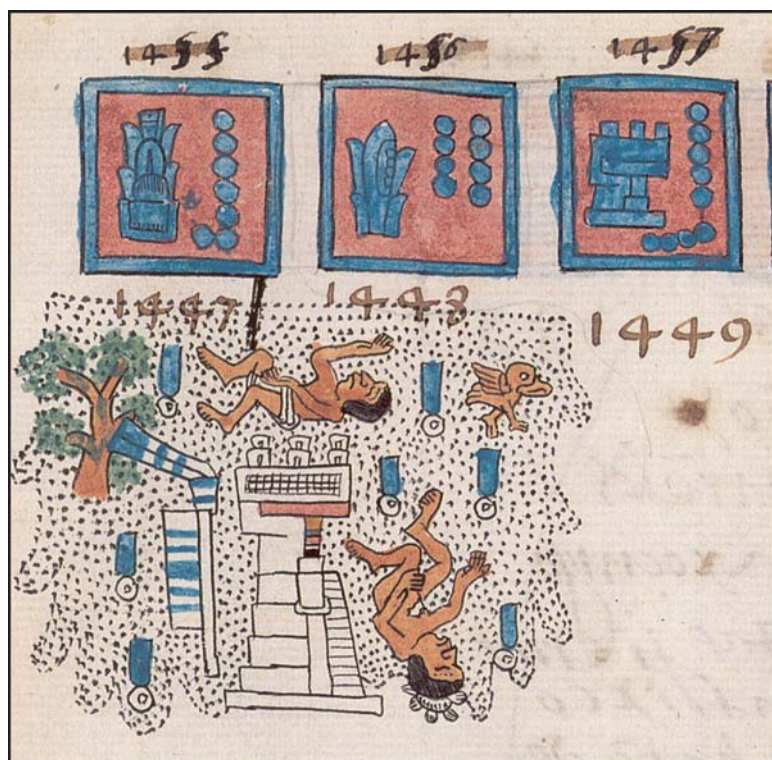
drought and have compiled a record of 13 events specifically described as droughts between 1332 and 1543. This Aztec drought chronology is compared with newly developed tree-ring chronologies from central and northern Mexico that have proven to be valuable as proxies for drought and crop production (Fig. 2). We investigate these Aztec records of drought in ancient Mexico, and evaluate the Aztec belief in cyclical drought-induced famines associated with the calendar icon One Rabbit.

**THE AZTEC CALENDAR SYSTEM.** The Aztec calendar was based on an ancient Mesoamerican

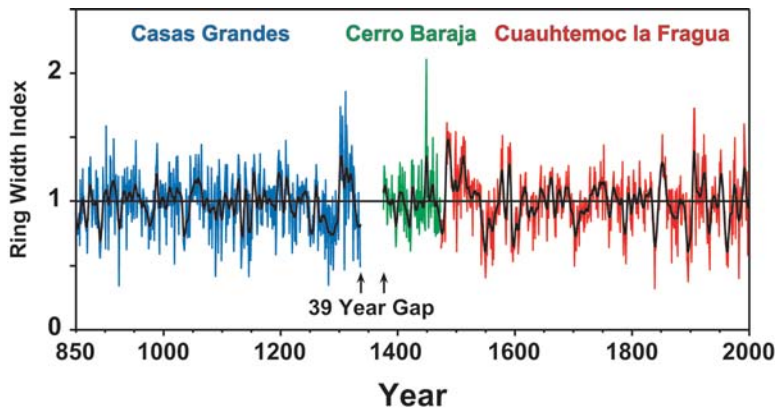
calendar system that computed both a 260-day religious calendar and a 365-day solar calendar. The 260 days of the *tonalpohuallii* (“count of the days”) were represented by a combination of a number (1–13) and 1 of 20 “day signs” (Caso 1971). For example, the day Tenochtitlan fell to the Spaniards (13 August 1521) was called “One Snake” and was followed by “Two Death,” “Three Deer,” and so on.

The 365-day solar year or *xihuitl* generally began in late January and was divided into 18 months of 20 days each, with five “leftover” days, which, while taken into account, were considered unlucky and outside the official *xihuitl* calendar. Each year takes its name from the last (360th) day the year (Caso 1971). One result of the mathematical arrangement of the calendar is that only four day symbols; *tochtli* (rabbit), *acatl* (reed), *tecpatl* (flint knife), and *calli* (house) can be taken as year signs and that each successive year sign will be raised by one. For example, “Three House” (1521) is followed by “Four Rabbit,” “Five Reed,” “Six Flint Knife,” “Seven House,” “Eight Rabbit,” and so on. This arrangement results in a 52-yr “century” or *xiuhmolpilli*, composed of 13 occurrences of each symbol. Each number–sign combination, such as the year One Rabbit, may occur only once in a 52-yr cycle.

**THE AZTEC DROUGHT CHRONOLOGY.** Some of the important historical annals that we have



**FIG. 1.** Detail of folio 32 v(erso) from the *Codex Telleriano-Remensis* portraying a fatal blizzard in 1447. Quiñones Keber (1995) describes the image as “a profusion of blue drops, representing precipitation, indicates a violent storm. They envelop a temple, a plant, a bird, a blue striped banner, and two male figures, whose upturned bodies and closed eyes indicate that they have perished in the storm. . . . [The] image shows how all of nature—plants, animals, and humans—were equally victimized by the catastrophe. The upturned figures literally represent an inversion of the natural order, when people died as a result of nature’s failure to function in a predictable way.” The blue-striped banner may indicate that the storm occurred in early Dec (e.g., Quiñones Keber 1995). The years 1447, 1448, and 1449 are represented by their Aztec year signs as Seven Reed, Eight Flint knife, and Nine House, respectively. A black line connects the storm image to the year Seven Reed (1447). The erroneous Julian year dates above the signs were corrected by the original authors of the codex, who placed the corrected date below the signs (Quiñones Keber 1995). Image reproduced with permission of the Bibliothèque Nationale de France, Paris.



**FIG. 2.** The annual values for the total-ring-width tree-ring chronologies from Casas Grandes, Chihuahua (blue), Cerro Baraja, Durango (green), and Cuauhtemoc la Fragua, Puebla (red), are shown along with their respective 10-yr spline (black) values, from 850 to 2001. The 39-yr gap from 1337 to 1375 between the end of the Casas Grandes archaeological pine chronology and the beginning of the Cerro Baraja chronology is indicated. For this figure the variance of Casas Grandes (std dev = 0.338) and Cerro Baraja (std dev = 0.331) chronologies have been adjusted to match the variance structure of the Cuauhtemoc la Fragua (std dev = 0.220) chronology.

consulted to resurrect this drought chronology include the *Codice Aubin* [also known as the *Codice de 1576* (Peñafiel 1902; Dibble 1963)], the *Codex en Cruz* (Dibble 1981), the *Codex Chimalpopoca* (Bierhorst 1992), the *Codex Telleriano-Remensis* (Quiñones Keber 1995), the *Codex Mexicanus* (Mengin 1952), and *Las Ocho Relaciones y Memorial de Colhuacan* (Chimalpahin 1998). These records cover events in various altepetl in the Valley of Mexico, including Texcoco, Cuauhtitlan, and Tenochtitlan. The *Codice Aubin* and *Codex Telleriano-Remensis* are pictorial manuscripts with Nahuatl and/or Spanish interpretive text. The *Codex en Cruz* and *Codex Mexicanus* have only the pictorial component and we have relied somewhat on Mengin's (1952) and Dibble's (1981) interpretations of the images. The *Codex Chimalpopoca* and Chimalpahin's *Relaciones* are written historical accounts that rely on older unknown pictorial codices. Using these well-known Aztec annals we have identified 13 drought years in seven separate episodes from 1332 through 1543. In Table 1 we list the drought

years along with the relevant historical citations and tree-ring values for each year. In a following section, selected drought episodes are discussed in detail using quotations from written annals, images from pictorial codices, written descriptions of the images, and available tree-ring data.

## TREE-RING CHRONOLOGIES.

The tree-ring data available for the time period covered in this study include a recently developed Douglas fir chronology from Cuauhtemoc la Fragua, Puebla (Therrell 2003), a Douglas fir chronology from Cerro Baraja, Durango (Stahle et al. 2000), and an archaeological Ponderosa pine (*Pinus Ponderosa*) chronology from the Casas Grandes site in Chihuahua (Scott 1966; DiPeso et al. 1974; Fig. 2). These are the longest tree-ring chronologies available for Mexico and the

only exactly dated, annually resolved climate proxies available for the region prior to the arrival of Euro-

**TABLE 1.** The chronology of 13 drought events compiled from major Aztec historical annals, source of each reference, and tree-ring value during each event year. The conversion of Aztec years to the Gregorian calendar was based on calculations by Caso (1971) using the Web-based calculator developed by Voorburg (2003; [www.azteccalendar.com](http://www.azteccalendar.com)).

Aztec drought years		Source	Tree-ring value
Gregorian	Aztec		
1332	9 Flint Knife	Chimalpahin (1998)	0.330
1333	10 House	Chimalpahin (1998)	1.11
1334	11 Rabbit	Chimalpahin (1998)	0.720
1335	12 Reed	Chimalpahin (1998)	0.740
1452	12 Flint Knife	Chimalpahin (1998)	0.918
1453	13 House	Peñafiel (1902)	0.694
1454	1 Rabbit	Bierhorst (1992), Dibble (1981), Quiñones Keber (1995)	0.932
1455	2 Reed	Dibble (1981)	0.944
1464	11 Flint Knife	Chimalpahin (1998)	0.888
1502	10 Rabbit	Bierhorst (1992)	1.107
1505	13 House	Chimalpahin (1998)	1.178
1514	9 Rabbit	Peñafiel (1902)	1.035
1543	12 House	Chimalpahin (1998)	0.509



peans. Both Douglas fir chronologies have proven useful as proxies for reconstructing climatic variables, such as precipitation and crop production (Díaz et al. 2002; Cleaveland et al. 2003; Therrell 2003), and both are well correlated with the All Mexico Rainfall Index (AMRI), which is heavily weighted to rainfall in central Mexico (A. V. Douglas 2000, personal communication). The Casas Grandes archaeological tree-ring chronology has been exactly dated against long tree-ring chronologies in New Mexico and Arizona (Scott 1966; Raveslout et al. 1995) from A.D. 850–1336. The Casas Grandes samples are all pine (probably *Pinus ponderosa*), which is an excellent drought proxy in the southwestern United States (e.g., Fritts 1991). A modern pine chronology from very near Casas Grandes is correlated with regional precipitation and the AMRI (Scott 1966; Cleaveland et al. 2003). There is a 39-yr gap between the end of the Casas Grandes chronology and the beginning of the Cerro Baraja chronology (Fig. 2), but no Aztec drought events have yet been identified during this period, and we hope to close this gap soon with additional collections of

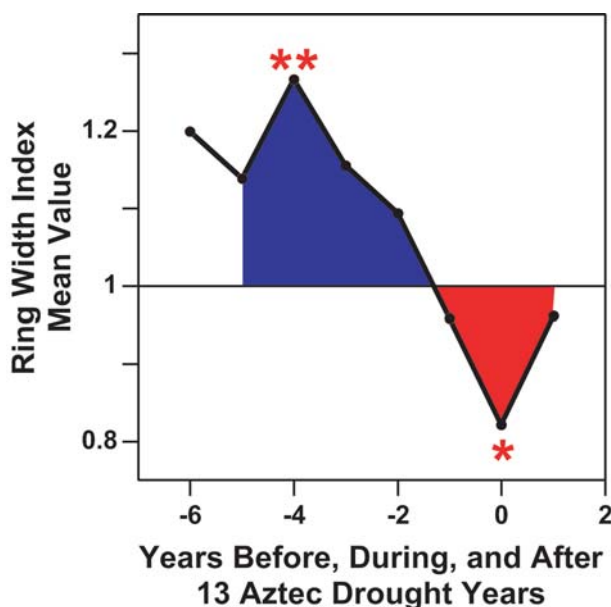
old trees and relict wood. We have used the mean total-ring-width chronology from each site for this analysis (e.g., Cook 1985; Cook and Kariukstis 1990). Because the chronology from Cuauhtemoc la Fragua, Puebla, is most proximate to the Valley of Mexico it is used for its entire length, from A.D. 1474 to 2001. From 1376–1473 we use the Cerro Baraja, Durango, chronology, which is about 750 km northwest of the Valley of Mexico, and from 850 to 1336 the more distant record from Casas Grandes, Chihuahua, which is the only tree-ring data available for Mexico during that time, is used.

**COMPARISON OF AZTEC DROUGHT DESCRIPTIONS WITH TREE-RING DATA.** Our chronology of Aztec references to drought begins in 1332 and ends in 1543. Only those events clearly described as drought in the historical record have been included in this initial reanalysis. Thirteen drought years can be identified in the Aztec records, and nine of these were also years of below-average tree growth (Table 1). Below-average tree growth in these chronologies is correlated with drought and poor maize yields in Mexico (Díaz et al. 2002; Therrell et al. 2002; Therrell 2003; Cleaveland et al. 2003).

Superposed epoch analysis (SEA; e.g., Haurwitz and Brier 1981) was used to compare the Aztec drought and tree-ring chronologies. In SEA, data values during specified “temporal events” are averaged and compared against the mean of the remaining values using multiple bootstrap iterations. In this case, the tree-ring data are organized by the 13 yr specified as drought years by Aztec records. Mean tree-growth during the 13 Aztec drought years, as well as the six prior years and one following year, is compared to all remaining growth values. The SEA indicates that on average, Aztec drought events occurred during years of significantly lower-than-normal tree growth (Fig. 3). Student’s *t* test indicates that the mean of the tree-ring values for the 13 event years are also significantly different from the average of all remaining years covered by the Aztec data (1332–1543;  $t = 0.020$ ).

**DESCRIPTIONS OF SELECTED EVENTS.** 1332, 1333, 1334, 1335. One of the earliest specific references to drought that we have found appears in Chimalapahin’s (1998) *Las Ocho Relaciones y Memorial de Colhuacan* and describes a prolonged period of drought between 1332 and 1336. The text for 1332 states,

“Then the time began in which it left off raining, they were four years those that did not rain, because in



**FIG. 3.** Results of superposed epoch of analysis (e.g., Haurwitz and Brier 1981) comparing the 13 Aztec drought years with the tree-ring data available for central and northern Mexico during the same years. The mean ring width index for the 13 Aztec drought years (year 0) is 0.86, which is significantly less than the average of all remaining years (\* =  $p \leq 0.05$ ). The mean for each of the 6 yr prior to and 1 yr after the event year is shown. Significantly above-normal growth (\*\* =  $p \geq 0.01$ ) occurred 4 yr prior to the Aztec drought years. This is reminiscent of the periodicity of El Niño–Southern Oscillation, which has a strong influence on modern climate over portions of Mexico.

Chalco, in all the region of Chalco, the word said by Tezcatlipoca was fulfilled.”

The text also states that drought continued in 1333–35. The limited tree-ring data for this period were obtained from Chihuahua, but they indicate that 1333–35 were well below normal (Table 1).

*1452, 1453, 1454, 1455.* Judging by its nearly universal inclusion in independent Aztec records, the famine of One Rabbit (1454) is one of the most widely reported social calamities in Aztec history. Descriptions of this event can be found in both written and pictorial annals, and the several references to this event may attest to its severity. While the drought that apparently contributed to the famine of 1454 appears to have begun in 1452, Chimalpahin’s (1998) reference in *Las Ocho Relaciones y Memorial de Colhuacan*, describing events in 1452 suggests that conditions may have deteriorated even earlier. The entry states that “This was the third year in which there was hunger. Then there was drought and hunger in Mexico.” Dibble (1981) describes the relevant portion of the image for 1453 in the *Codex en Cruz* as

“a blackened circle from which a shower of dots falls over a maize plant. The corn silk is visible, thus indicating a maize plant yielding ears of green maize. . . . The shower of dots can indicate snow, hail, frost, dust, or the heat of the sun.”

He suggests that the image describes a killing autumn frost, but in his description of the 1454 *Codex en Cruz* imagery, he includes drought as a precursor to the famine. In addition, Peñafiel’s (1902) translation of the *Codice Aubin*, upon which Dibble partially bases his interpretation, reads “It happened that the sowings dried up and also there was hunger.” Dibble also notes that *The Anales de Tlatelolco* describes a killing autumn frost this year. It seems likely that prolonged drought and an autumn frost may have contributed to the great famine of 1454. This scenario is strikingly similar to the drought and autumn frost that resulted in “El Año del Hambre,” or “The Year of Hunger,” in 1785 (Florescano 1976, 1986; Swan 1981). Gibson (1964) has described the catastrophe of 1785 as “the most disastrous single event in the whole history of colonial maize agriculture.” Interestingly, 1453 is a widespread frost ring in the latewood of bristlecone pine (*Pinus longeava*) in both the Great Basin and Rocky Mountains (Lamarche and Hirschboeck 1984; Brunstein 1996; Salzer 2000). These frost-ring events are indicative of hard freezes in late summer–early

autumn and many have been linked to cooling caused by volcanic eruptions. The 1453 frost ring is thought to be related to the eruption of the Kuwae caldera (Vanuatu; Briffa et al. 1998; Zielinski 2000).

The *Codex Chimalpopoca* (Bierhorst 1992) appears to indicate that the continuing drought also caused crop failure in 1454. The writer describes the event with the following: “At this time the people were one-rabbitted, . . . And for three years there was hunger. The corn had stopped growing.” The *Codex Telleriano-Remensis* provides one of the most compelling images of apparent drought and Dust Bowl-like conditions in 1454 (Fig. 4). Quiñones Keber (1995) describes the image as



**FIG. 4.** Detail of folio 32 v(erso) from the *Codex Telleriano-Remensis* portraying the famine of One Rabbit in 1454 (year sign for One Rabbit at top right). The image is thought to represent dust storms and the dead victims of the famine. The famine apparently resulted from a multiyear drought, possibly coupled with an early autumn frost event in 1453. A number of other sixteenth-century Aztec pictographic codices and Nahuatl language annals document this drought and famine, which is corroborated by the tree-ring chronology from Durango. Image reproduced with permission of the Bibliothèque Nationale de France, Paris.

“three plainly dressed ordinary folk, two males and one female, whose rotating forms and closed eyes depict the fatal effects of yet another disastrous storm. Pictorialized by swirling volutes of dots, the catastrophe this time appears to be caused by gusts of wind or dust.”

The *Codice de Huichapan* (Caso 1992) provides an even more graphic image of the human toll of the drought and famine, which included the scavenging of human corpses by wild animals (Fig. 5). The accompanying Nahuatl text suggests that that severe drought and famine resulted in cannibalism and other extreme behavior. It says “It was the will of our lord that in the time of this king (Montezuma) it did not rain not even a drop. The famine was very rigorous and people ate each other. . . .”

The *Codex Chimalpopoca*, the *Codex en Cruz*, and the *Annales de Chimalpahin* (Chimalpahin 1997) indicate that the drought and famine continued in 1455. Dibble’s (1981) description of the image for 1455 from the *Codex en Cruz* suggests that “The nude figure records the continuation of drought and famine during this year.” The *Codex Telleriano-Remensis* indicates recovery from the drought in 1455 (Quiñones Keber 1995), and the *Codice Aubin* places it 2 yr later in 1457. Temporal inconsistency occurs to varying degrees among the various annals, and the indepen-

dent climate information from tree rings may help resolve some of the uncertainty. For example, the tree-ring values were below normal from 1452 through 1455, but indicate a recovery in 1456 (not shown).

**1502 and 1505.** The *Codex Chimalpopoca* (Bierhorst 1992) provides a straightforward description of drought and famine in 1502 with the statement that “. . . at the same time it stopped raining altogether, so that we came up against 1 Rabbit, and people suffered famine.” However, it is unclear whether the author means to say that the drought lasted from 1502 until the year of One Rabbit (1506), or whether he means to say they were “One Rabbitted” or “cursed” by drought only in the year 1502. He may also be referring to the famine that occurred in 1505. Like 1502, there is only one reference to drought in 1505, but there is extensive written as well as pictorial evidence for famine in this year (Fig. 6).

Quiñones Keber’s (1995) comment on the images for 1505 in the *Codex Telleriano-Remensis*,

The . . . group of images repeats a tale of famine, starvation, and death similar to that which occurred during the reign of the first Motecuhzoma one cycle (fifty-two years earlier) . . . The weeping figure and mummy bundle show the extreme suffering people underwent as a result of the chronic shortage of food,



**FIG. 5.** Detail from Lamina 37 of the *Codice de Huichapan* (Caso 1992), showing the ghastly consequences of the famine of One Rabbit. A written account of the event in the *Annales de Chimalpahin* says that coyotes and other beasts devoured the bodies of those who died of starvation in 1454 (Dibble 1981). The skull indicates a great number of deaths. Image reproduced with permission of the Biblioteca Nacional de Antropología e Historia, Mexico City.

describes both this image as well as portions of the image for 1505 seen in the *Codex en Cruz*. The reference to the famine 52 yr prior describes the 1454 event. The *Codex Chimalpopoca* also describes the impact of the famine: “Also in that year [1505], people went to the Tontonaque. On account of the famine, they carried shelled corn from Totoncapan.” *Las Ocho Relaciones y Memorial de Colhuacan* merely states that “Also then there was drought.” Because there is no unambiguous reference to long-lasting drought in either text, only 1502 and 1505 are included in the drought chronology. The tree-ring data indicate that both years are slightly above normal. The *Codex Mexicanus* (Mengin 1952) shows what is described as a drought in 1504, but it is unclear whether this event is actually referring to 1504 or to 1505.

**1514.** Dibble (1981) describes the figure for the year Nine Rabbit from the *Codex en Cruz* (not shown) as well as a similar figure in the *Codice Aubin* by saying

“From a blackened circle, a shower of dots falls over a maguay plant. . . . Other than the substitution of a maguay plant for a maize stalk, the representation



is identical with the one for Thirteen House (1453). . . . In general terms it indicates adverse weather conditions, a subsequent crop failure, and starvation. Based on the representation in the *Codice de 1576* for the year (1453) a frost seems probable. However, this same codex has a similar representation for the year Nine Rabbit (1514) and the text reads 'Here dust arose wherefore there was starvation.'

The tree-ring data indicate just above average conditions in 1514. It is possible that the images described by Dibble (1981) may represent some other phenomenon, such as frost. However, the tree-ring data, in conjunction with the quotation from the *Codice Aubin*, suggest that the images were meant to portray drought. The tree-ring data from Durango record more severe drought in 1514 than does the Puebla chronology. More tree-ring data from central Mexico will be necessary to improve the estimation of drought area and intensity during these Aztec drought events.

**1543.** The reference to drought from *Las Ocho Relaciones y Memorial de Colhuacan* reads as follows:

"In this year there were great dust storms and drought, thus the maize sowings did not occur and there was hunger; the first rain fell the day of the celebration of San Juan Bautista [Late June]."

Reference to the drought of 1543 may be pictured in the *Codex Telleriano-Remensis* by what Quiñones Keber (1995) describes as an unknown place sign (Fig. 7). The tree-ring data indicate drought in 1543, suggesting that the sun over the maize plants may have been intended to represent drought.

**THE CURSE OF "ONE RABBIT."** Aztec cosmology placed great emphasis on the prophetic nature of their calendar. The year One Rabbit begins each 52-yr calendar cycle and was strongly associated with the occurrence of catastrophic events such as famine. In reference to the famine in the first One Rabbit year of the Colonial Era (1558), the annotation in the *Codex Telleriano-Remensis* states that

"In this year one rabbit [I Rabbit], if one looks carefully at this count, it will always be seen that in this year [Rabbit] there was famine and death. . . . And thus they consider this year as a great omen, for it always falls on one rabbit."

The tree-ring data indicate that the Aztec's fear of famine and catastrophe in One Rabbit years may have



**FIG. 6.** According to Quiñones Keber (1995), the mummy bundle and profusely weeping figure shown in the image illustrating events in 1505 from the *Codex Telleriano-Remensis* folio 41 v(erso) portray the suffering caused by another famine associated with the year One Rabbit (1506). The footprints and central figure of a traveling merchant along with the cactus symbol for Tenochtitlan over a maize granary indicate that the people of that city were forced to import maize from other areas, such as the Huxtec region of the Gulf Coast, which may be represented by the "man-bird" image whose perforated septum typifies that area's inhabitants. However, Dibble (1981) relates that this man-pigeon image could also represent a sinister apparition called Tlacahuilotlan whose appearance was an omen of "impending disaster." Duran's (1994) account of the 1454 famine includes the description of large numbers of children being sold to Totonac merchants from the east in exchange for maize and it seems plausible that this is what is represented by the weeping individual, footprints and "Huxtec-man." Image reproduced with permission of the Bibliothèque Nationale de France, Paris.

been based on long experience. Thirteen One Rabbit years between A.D. 882 and 1558 are covered by the available tree-ring data (1350 not covered). Ten of

these years were immediately preceded by below-normal tree growth in the year 13 House, and the mean of the preceding 13 House years is significantly below normal ( $p < 0.1$ ; Fig. 8). These 13 House years include very severe low-growth periods in 1037, 1089, 1297, and 1557. Below-normal Douglas-fir growth in central Mexico is associated with poor maize harvest (Therrell 2003). So the Aztec belief in the curse of One Rabbit may have arisen because of drought-induced poor maize yields prior to One Rabbit years.

This amazing coincidence between drought/famine and the Aztec calendar cycle apparently ended with the Aztec empire. There is no significant relationship between the eight One Rabbit years and tree growth that occurred after the 1558 event. In fact the mean of the eight 13 House years in this period is slightly above normal (not shown).



FIG. 7. Detail of the image for 1543 from folio 46 r(ecto) of The Codex Telleriano-Remensis. Quiñones Keber (1995) describes the image as “a complex place sign showing the sun shining on two plants sprouting on a patch of land.” The Europeanized sun symbol may be related to the death of Pedro de Alvarado whom the Aztecs called “Sun” in 1541. However, Chimalpahin (1998) reports “great dust storms and drought” and the tree-ring data from Puebla also indicate severe drought in 1543. This image and others like it in the codices might therefore indicate drought and sun-parched crops rather than a place sign. Image reproduced with permission of the Bibliothèque Nationale de France, Paris.

Although famine is recorded during the three One Rabbit years between 1454 and 1558, given the demonstrated occurrence of drought during the majority of 13 House years analyzed, one might be surprised that more One Rabbit famines or 13 House droughts are apparently not described in the annals. The increasingly incomplete nature of the historical annals prior to the ascendancy of the Mexica as the dominant culture group in the late fourteenth century makes a conclusive answer difficult.

**CONCLUSIONS.** The available tree-ring data from Mexico validate the occurrence and timing of drought years described in the Aztec codices, and for the first time reveal a possible climatic explanation for the Aztec fear of the year One Rabbit. The tree-ring data did not confirm all 13 drought years described in the

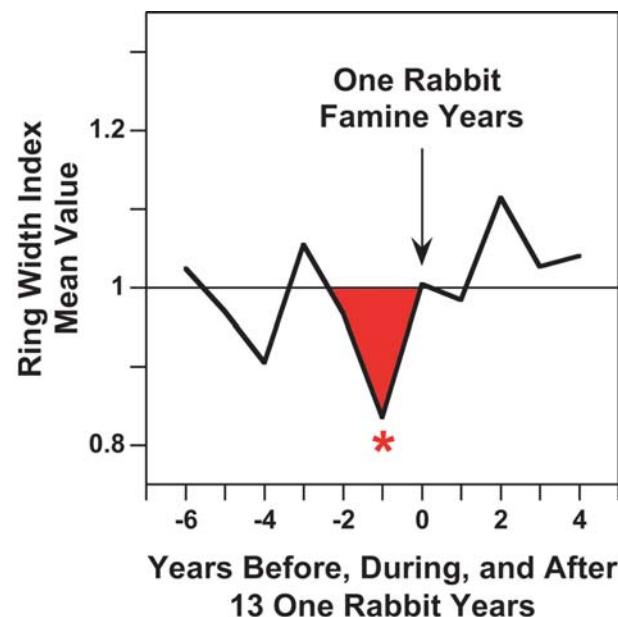


FIG. 8. The superposed epoch analysis of tree growth for the 13 One Rabbit years between 882 and 1558, preceding and during the Aztec Empire. The 13 One Rabbit years were 882, 934, 986, 1038, 1090, 1142, 1194, 1246, 1298, 1402, 1454, 1506, and 1558. The mean ring-width index was just above the long-term average during these 13 yr. However, the mean value of the years immediately preceding One Rabbit was significantly below normal (year - 1 = 0.85  $p < 0.1$ ), which indicates drought and probable crop failure leading into One Rabbit (e.g., Cleaveland et al. 2003; Therrell 2003). This result suggests that the Aztecs did indeed suffer famine and misfortune during many One Rabbit years. After 1558 there is no significant association between low tree growth preceding One Rabbit years (not shown). So the curse of One Rabbit appears to have been purely coincidental and ended with the Aztec era.



Aztec annals, although the 4 yr not replicated by the tree-ring record were only slightly above the long-term average. Comparison of proxy tree-ring data with Aztec-era historical climate data would be improved by the development of additional long tree-ring chronologies in central Mexico. A more complete network of tree-ring sites could help define the true spatial extent of the reported Aztec drought events. Famine occurred in 1454 and 1505 and Tenochtitlan apparently relied on maize imports from the Gulf Coast area of Veracruz. Rainfall and crop yields in Veracruz during 1454 and 1505 were presumably better and a more complete tree-ring network could be used to test this hypothesis.

Further analysis of Aztec historical records might also yield additional information about prehispanic drought in central Mexico. The major codices were examined for this project, but less significant Aztec records may yet contain additional information about drought or other climate conditions.

Several famine events in the Aztec record may be drought related, but these were not included here because drought was not specifically described. For example, a severe famine in 1019 apparently instigated the practice of sacrificing human “streamers” (children) to the rain gods (e.g., Bierhorst 1992). The famine of 1019 may indeed have arisen from drought because the tree-ring data indicate extreme low growth in that year.

There are also potential references to drought that were not included in our analysis. For example, the *Codex en Cruz* includes an image of a maize plant under a shower of dots in 1549. The tree-ring data indicate poor growth in 1549, suggesting that this image might represent drought. Similar images are illustrated for 1453 and 1514 in the *Codex en Cruz* and *Codice Aubin*.

The Aztecs also recorded instances of hail, frost, snow, floods, and locust plagues, but these phenomena have yet to be thoroughly investigated. The emerging tree-ring record for Mexico and elsewhere over subtropical North America may help validate these Aztec climate events, especially early autumn frost events. The famine of 1454 appears to have been caused by both a multiyear drought and an early autumn frost in 1453. Frost-ring evidence from bristlecone pine indicate an early autumn freeze in 1453 in the Sierra Nevada and Rocky Mountains (Lamarche and Hirschboeck 1984; Brunstein 1996; Salzer 2000), and this cold-air outbreak may have reached the high-elevation Valley of Mexico. Other early autumn-freeze events recorded by frost rings in bristlecone pine definitely appear to have penetrated into central Mexico where autumn frosts were simul-

taneously recorded in historical archives (e.g., 1663, 1878, and 1882; see Florescano 1980; Brunstein 1996).

Tree-ring chronologies provide the only exactly dated annual data presently available for Mexico that can be used to validate Aztec references to prehispanic climate. For the first time, tree-ring records have been used to support the Aztec chronology of drought, including events as early as the fourteenth century (i.e., 1332, 1334, 1335).

The development of more long tree-ring records in central Mexico and additional codex-based climate records should be possible, and when used in conjunction would improve our understanding of climate and its impact in ancient Mexico. Climate researchers have extensively studied colonial era historical records in Mexico (e.g., Florescano 1980; O’Hara and Metcalfe 1995; Endfield and O’Hara 1997), but the bulk of the prehispanic documentary record remains relatively unexplored. Clearly the prehispanic record has much to offer in the study of climate history in Mexico, and should be further investigated.

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