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# Aberrant characters in Chinquapin Oak populations, *Quercus muehlenbergii* Engelman, of the Four Canyon Nature Preserve, Ellis County, Oklahoma suggest a time of ancient introgression by Bur Oak, *Quercus macrocarpa* Michaux

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**Abstract:** In canyons of Ellis County, Oklahoma opening to the South Canadian River below, disjunct populations of *Quercus muehlenbergii* Engelman predominate. In 2022 and 2023 trees of two canyons within the Four Canyon Nature Preserve were sampled. Morphological analysis of the specimens revealed features not associated with the species including, terminal bud stipules, divergent venation, fasciculate trichomes, lobed leaf margins and pubescent twigs. The characters are consistent with those of Bur Oak, *Quercus macrocarpa* Michaux, suggesting hybridization, however, Bur Oak does not co-occur in the canyons. The supposition is the Chinquapin populations are descendants of an ancient time of sympatry with Bur Oak.

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## Introduction

Disjunct populations of *Quercus muehlenbergii* Engelman predominate in the canyons above the South Canadian River in Ellis County, Oklahoma. However, this species is not typically dominant in Oklahoma Forest Associations, Hoagland (2000). Throughout its contiguous range in the U.S., from Vermont to west Texas, it occurs occasionally in mature forests or frequent on limestone outcroppings, Sander (1990).

The Canyons' populations represent the western limit of the species' range in Oklahoma, as a SEINet search (2022) of the Panhandle

Counties returned no occurrence. Isolated populations of the Chinquapins, however, are also known further west in New Mexico, and Texas and south into northern Mexico, Tucker (1961), Nixon and Muller (1997) and Thomson (2022). The Preserve populations are the eastern-most of these outliers

In Oklahoma, the species is found in the eastern tier of counties as part of the Acer Saccharum Alliance, Hoagland (2000), but typically as a minor component. It is also recorded occasionally throughout Oklahoma but absent from the Panhandle counties. Thus, its dominance in the canyons is remarkable.

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The dry, sub humid conditions of the Canyons are a far different climatic regime from that of the more mesic eastern forests. How, then have they come to predominate in the Canyons?

During a review of specimens of western white oaks in Oklahoma, a voucher specimen, (4C-034), from a biological survey of Ellis County, Oklahoma, Hoagland (2007) was examined. The specimen, on deposit in the Robert Bebb Herbarium at the University of Oklahoma (OKL), was from the Four Canyon Nature Preserve. It appeared unusual in having what seemed to be leafy twigs from two different trees, Fig. 1. The twigs bearing leaves with dentate margins are typical of *Quercus muehlenbergii* Englm. The lobed leaves of the other twig are unlike those of Chinquapin Oaks. While unusual to prepare a record in this way, neither did the specimens seem to be from sun and shade leaves of the same tree.



Figure 1 Leafy Twigs from Four Canyon Nature Preserve Biological Survey. Used with permission.

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In the survey, Hoagland described the canyons' vegetation as a *Q. muehlenbergii*-*Juniperus virginiana* L. association occurring on deep sandstone soil, thus assigning the species dominant status in the association. He states, "Although *Q. muehlenbergii* has been reported from counties immediately south of Ellis, it does not occur as a dominant species." In the canyons it clearly does. What is striking about the trees is that many display a shrub-like habit of producing multiple branches at or near the base. However, on inspection, none of them appeared to be connected by rhizomes or is branching the result of mechanical or fire damage, Figure 2.



Fig. 2. Multi-trunk Chinquapin oak in the Four Canyon Nature Preserve

A request was granted by the Nature Conservancy for permission to sample populations of the trees in two canyons, Cinnamon and Mulberry in 2022 and 2023 respectively. While the stands appear to be those of *Q. muehlenbergii* a detailed examination of specimens showed characters not associated with the Chinquapin Oaks. However, no other species of oaks occur in the canyons. This study provides morphological evidence of their introgression by *Q. macrocarpa* and a timeframe of their sympatry.

## Methods

### Study Site

The Four Canyon Nature Preserve, managed by the Nature Conservancy, is in Ellis County near Arnett, Oklahoma (36.01.12 N, 99.30.06 W). The Preserve consists of approximately 1620 hectares of rolling hills and deeply eroded hillsides. While the runoff areas are called “Canyons” they are more like deep ravines opening to the Canadian river below. Four of them are named, from west to east: Cinnamon, Horse, Mulberry, and Harsha although there are several smaller unnamed ones. Situated in the Southern Great Plains, the climate of Ellis County is humid, subtropical with average annual precipitation of 60.4 cm (23.78 in.), Oklahoma Climatological Survey (2023).

The area above the canyons is mixed-grass prairie but near the rims woody species are found including, *Q. havardii* Rydberg, Havard Oak, and Eastern Red Cedar, *Juniperus virginiana* L. *Quercus stellata* Wangenheim, Post Oak, is known from the preserve, Buthold (4C-446: OKL), but not the canyons. According to station manager, Chris Hise, “A single Post Oak was located west of Cinnamon Canyon but was destroyed by wildfire in 2008, but Post Oak hybrids (*Q. havardii* × *stellata*) are found in the shinnery west of the Preserve”. He further offered, that the previous owner said no fires had reached the canyons from the time he purchased it in 1950 until it was acquired in 2004 by the Nature Conservancy.

While the Canyons’ Chinquapins seemed isolated, records of occurrence were searched to determine the nearest reported locations. Records were obtained via SEINet (2023) and from specimens in the herbaria of the University of Oklahoma (OKL) and Oklahoma State University (OKLA). The results confirmed that, notwithstanding an occasional record in counties east and south of the site, the populations are quite isolated.

Disjunct populations of the species are also known from the Capitan Mountains of New Mexico, Thomson (2022) and in the Davis Mountains of west Texas and northern Mexico, Nixon and Muller, (1997). Thus, it seems, Four Canyon

Nature Preserve Chinquapins are the eastern-most of the disjunct populations and western-most of its occurrence in Oklahoma.

### Cinnamon Canyon

Cinnamon Canyon, western-most of the named canyons, lies in the northeast corner of the Preserve (36.00.11 W, -99.28.48 W) and situated along a northwest to southeast orientation. Trees of the canyon have multiple trunks arising at the base (Fig.2). They supported few acorns, but none was accessible for collection. Neither were any found on the canyon floor and no seedling or sapling-sized individuals were observed.

### Mulberry Canyon

Mulberry Canyon is the third canyon of the four, west to east and situated northwest to southeast above the Canadian River at 36.00.13 N -99.28.01 W. Here, also, many trees are multi-trunked but were found to have acorns accessible for collecting. As with Cinnamon Canyon no seedling or sapling sized trees were observed.

### Sample Collection and Preparation

Permission was granted to sample a population from Cinnamon Canyon during September of 2022. The examination revealed five features not associated with Chinquapin Oaks, thus prompting a request to sample a second canyon. Permission was given to sample Mulberry Canyon, in October of 2023. The collections from both canyons were made by Amy Buthod of the Oklahoma Biological Survey and Collections Manager of the Robert Bebb Herbarium (OKL) and Pricilla Crawford of the Oklahoma Biological Survey. In all, twelve individuals of *Q. muehlenbergii* from Cinnamon Canyon in September 2022 and twelve from Mulberry Canyon in October 2023, were identified for collection and two specimens obtained from each. Photos were taken of each tree sampled.

Specimens from two individuals of *Q. havardii* Qh C 1 and 2 occurring above Cinnamon Canyon were also collected and two specimens of *Q. macrocarpa*, Qmc 1 and 2, from Turkey Creek, a site about 8 km northeast of the preserve, and the only recorded site for Bur Oak

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in the county. No other species of white oaks were found in the search referred to above or on site in the Preserve.

In collecting specimens care was taken to select twigs of sun leaves, as nearly possible, from the same west-facing aspect of each tree. In cases where leaves of like orientation were not accessible, specimens were taken from twigs closest to west-facing.

For each tree, the height was estimated, and a measurement of the trunk (s) diameter was taken at breast height (dbh). Specimens from Cinnamon Canyon were labeled in order of collection Qm C (Cinnamon) 1 to Qm C 12, for *Q. muehlenbergii*. Specimens from Mulberry Canyon were labeled Qm M (Mulberry) 1 to Qm M 12. For each sample, location and elevation data were recorded, and associated species listed. The specimens were then pressed and returned to University of Oklahoma herbarium for drying and study. While the data for tree height, diameter at breast height and listing of associated species were not germane to this study the data were collected and made part of the record for any future studies.

### *Morphological Examination*

Metrics obtained for this study were based on features of leaves, twigs and terminal buds. Acorns were not included as they were only available from Mulberry Canyon. The limited number were considered insufficient to be useful in the analysis of the status of the plants and were not included. Their metrics, however, are available from the author.

#### *Leaves*

Length of leaf blades was measured from base to apex of terminal leaves and width at the midpoint using calipers. Measurements are rounded to the nearest tenth centimeter. The vein pattern was also examined and recorded.

Leaves were examined to determine trichome type(s) by viewing the abaxial surface of terminal leaves at the apex, mid-leaf and base of the blade with a compound light microscope at 60X. The type(s) were determined and recorded.

Leaf contour was determined by constructing an index of indentation. The index was developed from measurements on specimens of *Q. muehlenbergii* in the herbaria of OKL and OKLA and from previous studies, Thomson (2009), Specimens were examined from across its geographic range. Values from sixty-three specimens were used.

The Index was developed using calipers to measure the depth of the second indentation from the apex and the second indentation from the base on the right side of the terminal leaf. An indentation value was obtained by dividing the apex value by the base value. The average was used as the index value representing "typical" *Q. muehlenbergii*. Values for the canyon oaks were compared to this index.

#### *Twigs and Buds*

Dimensions for twigs and buds were not obtained, but pubescence was noted on a presence/absence basis.

Because *Q. muehlenbergii* is known to have a tolerance for alkaline soils, a sample from each canyon was collected and sent to the Oklahoma State University Soil, Water and Forage Laboratory (OSU) for analysis.

## Results

From the examination of specimens, five features stood out as atypical for *Q. muehlenbergii*: degree of indentation of the leaf margin, pattern of secondary veins, presence of terminal bud stipules, pubescent twigs, and trichome types.

To determine whether the anomalies could be the result of hybridization, the features of four other oak species; *Q. havardii*, and *Q. stellata* because they occur in the Preserve and *Q. macrocarpa* for its presence in the county. The fourth, *Q. gambelii*, while not extant in the county, has been noted in the Panhandle County of Cimarron, Little (2010). Also, a specimen viewed during the study, Little, (36724: OKLA) from Woodward County, determined *Q. gamble-*

*lii* × *Q. muehlenbergii*, implicated *Q. gambelii*. Because of this finding, and that *Q. gambelii* has been recognized as a participant in hybridizations with *Q. muehlenbergii* in other studies, Tucker (1961) and Thomson (2022), I included it in the study.

The five features are further analyzed below and summarized in Tables 1 and 2.

#### Margination

The margins of typical *Q. muehlenbergii* are toothed or shallow lobed, often mucronate, with an Index value at or less than 2.1:1. The indentation index procedure was used to obtain a value for each canyon specimen. Eight from Cinnamon and three from Mulberry had values greater than the 2.1:1 ratio for typical *Q. muehlenbergii*.

#### Venation

The veins of *Q. muehlenbergii* leaves display a distinct pinnate pattern; secondary veins running from midrib to margin. The pattern is shown in Figure 3. The leaf on the left is from Qm M 4 showing a secondary vein dividing into two tertiary veins. The leaf on the right displays pinnate venation typical of *Q. muehlenbergii*.

In three of the Cinnamon Canyon specimens, Qm C 1, 2 and 7, one or more of the secondary veins showed a branch of the same magnitude also reaching the margin, Table 1. This pattern also found in six of the specimens from Mulberry Canyon, Qm M 1, 3, 4, 5, and 12, Table 2. Divergent branching is found in the leaves of oaks with distinct lobes such as *Q. macrocarpa*, and *Q. gambelii* but not the Chinquapins.

#### Vestiture

##### Twigs

Twigs of *Q. muehlenbergii* are glabrous or sparingly glabrate. Twigs of *Q. gambelii*, *Q. macrocarpa* and *Q. stellata* have some degree of persistent pubescence, but those of *Q. havardii* are glabrous or glabrate. Specimens QmC1, C6 and C8 from Cinnamon Canyon displayed pubescent twigs. Those of Mulberry Canyon were glabrous.



Figure 3 divergent veins of suspected hybrid from Mulberry Canyon. Photo by author.

#### Leaves

Leaves of Chinquapin Oaks are vested with trichomes. Trichome types are considered diagnostic characters for white oaks, Nixon and Muller (1997). Those occurring on *Q. muehlenbergii* and the four potential parents are described here. Nomenclature follows Hardin (1979).

Trichomes of *Q. muehlenbergii* are of a single type, stellate with 6-12 rays appressed to the leaf surface. *Q. gambelii* leaves produce fasciculate trichomes with 1-4 rays, and *Q. havardii* have erect, stellate hairs often with twisted rays. Trichomes of *Q. macrocarpa* are of three types: fasciculate, stellate-appressed and bulbous. Bulbous hairs resemble a drumstick often with the terminal cell pigmented yellow. *Q. stellata* leaves produce stellate-pediculate hairs, and occasionally bulbous ones.

Specimens QmC1, 2 and 12 from the Cinnamon Canyon specimens possessed stellate-appressed, fasciculate and the bulbous type. The others possessed stellate-appressed and fasciculate but not the bulbous type. The trichomes

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of Mulberry Canyon Oaks are stellate-appressed, however, three QmM 1, 4 and 12 were found to also have the bulbous type. Their occurrence is shown in Tables 1 and 2.

### Terminal Bud Stipules

Stipules were found, subtending and amid, the scales of the terminal buds of several of the specimens. In a study of bud formation in the Pendunculate Oak, *Q. robur* L, they were identified as transitional structures leading to bud scales, Studer-Ehrensberger & Schilperoord, (2016). Why they are present at bud maturity in some but not others was not germane to that study. For purposes of this study, they are consistent in occurrence for the species bearing them and thus of diagnostic value.

The species of this study producing stipules are *gambelii* and *Q. macrocarpa*. Their stipules extend up to or beyond the tip of the bud, are linear and pubescent. Five of the Cinnamon Canyon specimens, Qm C 2 and Qm C 6-9, and one from Mulberry Canyon Qm M 1 produced stipules, Tables 1 and 2. Stipules are not persistent on terminal buds of *Q. muehlenbergii*.

### Transverse fissures

This feature of twigs was not observed during the study. However, they are prominent on twigs of *Q. gambelii* and were used in an examination of the origin of *Q. margaretta* and *Q. drummondii* by Tucker and Mueller (1958) to distinguish *Q. gambelii* from *Q. margaretta*. Figure 4 shows transverse fissures on a specimen collected by John Tucker, in the John M. Tucker Herbarium, University of California, Davis Tucker, (2776-6: DAV).

Because fissures were not found on the specimens of this study, they are not included as an anomalous feature, but their absence aided in identifying the possible second parent.

A further search for *Q. gambelii* in Oklahoma via SEINet returned 12 specimens, all in Cimarron County, 241 km northwest of the Preserve. Herbarium loans were obtained from the

Botanical Research Institute of Texas (BRIT) and Morten Arboretum (MOR) to examine ten of them. The others were in the herbaria of the University of Oklahoma (OKL) and Oklahoma State University (OKLA) which I viewed on site. I could not confirm *Q. gambelii* in typical form in Oklahoma, Thomson (2025).

The anomalous features possessed by the potential parents are summarized in Table 3. Three occur on *Q. gambelii*, none on *Q. havardii*, five on *Q. macrocarpa* and two on *Q. stellata*.



Figure 4. Photo of Transverse Fissures on a twig of *Q. gambelii*, by Dan Potter, University of California, Davis. Used with permission.

To obtain an overall impression the number of occurrences of the aberrant characters occurring on the specimens from each canyon were combined to determine the total occurrences. The number of occurrences are displayed in, Tables 4 and 5 and described as follows:

### Cinnamon Canyon

The Cinnamon Canyon specimens showed 1 to 4 features with a total of 31 occurrences. Qm C 10 is most like *Q. muehlenbergii* in possessing only one of the features. Qm C 2 and Qm C 8 are most aberrant with 4 features. Qm C 1, Qm C 6, and Qm C 9 show three features and Qm C 3, Qm C 4, Qm C 5, Qm C 11 and Qm C 12 each had two features. Trichome type was the most frequent. All twelve specimens had stellate and fasciculate trichomes and three Qm C 1, Qm

C2 and Qm C12 had the bulbous as well. Stipules were next frequent with five terminal buds subtended by them. Pubescent twigs were least frequent with three occurrences. In all the twelve specimens had 31 occurrences of the features.

### Mulberry Canyon

The Chinquapins of Mulberry Canyon possessed fewer of the features. Five of the specimens, Qm M 2, 6, 8, 10 and 11 showed none of the characters. Two of them, Qm M 1 and 12 displayed three each, Qm M 3 and 4 two each and Qm M 7 and 9 one feature. Atypical branching of the veins occurred most frequently with six of the specimens, Qm M 1,3,4,5, 7 and 12 displaying the pattern. None were found to have pubescent twigs. Together, the 12 specimens displayed 13 of the suspected hybrid characteristics.

In all, the 24 specimens of this study bore 44 occurrences of putative hybrid characters.

### Soil Conditions

Laboratory reports found the sandstone soils of Cinnamon and Mulberry canyons slightly alkaline at pH 7.6 and 7.8 respectively. The reports also indicated the soils to be nutrient poor with exceptionally low levels of nitrogen and phosphorus, but adequate in potassium, OSU Soil Report 1735 (2022) and OSU Soil Report 195042 (2024). Nutrient availability is known to affect stand quality, Johnson et al. (2019), however, no further assessments of edaphic conditions were made.

### Analysis of Potential Parentage

To determine the likely parentage each of the four species, identified above, were examined for the source of the five features. The results are described as follow.

#### *Quercus gambelii*

Leaves of typical Gambel's Oak are lobed in the lower and upper half, possess divergent veins extending to lobes, and bear trichomes

that are simple and fasciculate with 1-4 rays. Terminal bud stipules are typically present, and twigs are pubescent or become glabrate, the periderm often marked with noticeable transverse fissures.

#### *Quercus havardii*

Havard Oak is abundant in the area above the canyons. Also called Shin Oak, it varies from being rhizomatous shrubs to small trees (Nellessen, 2004) and occurs throughout much of Ellis County, Wiedeman and Penfound (1960).

Leaf margins are variable; undulate or with 2-3 teeth, or occasionally lobed in the upper half. Secondary veins are branched but rarely reach the margin. Trichomes are stellate with twisted rays. Terminal bud stipules are absent, and twigs are glabrous or become glabrate.

A record from Woodward County, Little (36,505: OKLA) examined during the study, had been determined by him as a cross between *Q. muehlenbergii* and *Q. havardii*. Upon examination it did appear to be of hybrid origin, but none of the aberrant features, as described above, were found and, therefore, was not considered germane to this study.

#### *Quercus macrocarpa*

Leaves are lobed most pronouncedly in the lower half, and some of the lobes contain a vein diverging from a secondary, ending in a lobe tip. Terminal buds are often subtended by pubescent stipules and trichomes are stellate with 6-12 rays, fasciculate with 6-8 rays, and bulbous. Pubescence is persistent on twigs.

Range maps of Bur Oak do not show it in Ellis County, Little (2010), Tirmenstein (1991), and Nixon and Mueller (1997). However, a single record was located in a SEINet search, (Erteeb 1570 OKLA). With the assistance of Preserve Manager, Chris Hise, the site, about 8 km northwest of the Preserve, was located and the specimen referred to above collected. This is believed to be the only location for *Q. macrocarpa* in the county and western-most in Oklahoma.

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*Quercus stellata*

Post Oak would be an inviting possibility for the source of variation in the Canyon Chinquapins for its known history in the preserve. However, none was collected for this study for the reason stated above. However, to evaluate it for a potential role in hybridization, I used features from herbarium records of specimens from western Oklahoma and my previous research, Thomson, (2009).

Post Oak is well known for leaves with cross-like lobes occurring at right angles to the midrib. Secondary veins are divergent, but the branches do not typically run to a lobe tip. Beneath, the leaves bear both stellate and bulbous trichomes but the stellate hairs are erect and often pedestellate. Terminal buds are not subtended by stipules, but twigs are pubescent.

Table 1. Values For Atypical Characteristics of Cinnamon Canyon Oaks

Legend: Index; =< 2.1= *Q. muehlenbergii*, >2.1=hybrid; Trichomes Types, s=stellate, appressed, f=fasciculate, b=bulbous. Twig Pubescence, g=glabrous, p=pubescent; Stipules, - =feature absent, +=feature present; Vein Pattern, d=divergent, p=pinnate

Specimen	Indentation Index	Trichome Types	Twig Pubescence	Presence/absence Stipules	Vein Pattern
Qm C 1	5.90	s,f,b	g	-	d
Qm C 2	2.00	s,f,b	p	+	d
Qm C 3	2.50	s,f	g	-	p
Qm C 4	3.03	s,f	g	-	p
Qm C 5	3.33	s,f	g	-	p
Qm C 6	2.00	s,f	p	+	p
Qm C 7	1.00	s,f	g	+	d
Qm C 8	3.45	s,f	p	+	p
Qm C 9	4.00	s,f	g	+	P
Qm C 10	2.00	s,f	g	-	p
Qm C 11	5.90	s,f	g	-	p
Qm C 12	5.00	s,f,b	g	-	p

Table 2. Values for atypical characteristics of Mulberry Canyon Oaks

Legend: Index; 2.1 =< *Q. muehlenbergii*; < 2.1 = hybrid; Trichome Types: s=stellate, f=fasciculate, b=bulbous; Pubescence: p=pubescent; g=glabrous; Stipules: +=present; - = absent; Vein Pattern d = divergent, p = pinnate

Specimen	Indentation Index	Trichome Type(s)	Twig Pubescence	Stipules Present/Absent	Vein Pattern
Qm M 1	3:1	s,b	g	+	d
Qm M 2	2:1	s	g	-	p
Qm M 3	2:1	s	g	-	d
Qm M 4	2:1	s,b	g	-	d
Qm M 5	2:1	s	g	-	d
Qm M 6	2:1	s	g	-	p
Qm M 7	2:1	s	g	-	d
Qm M 8	2:1	s	g	-	p
Qm M 9	2.5:1	s	g	-	p
Qm M 10	2:1	s	g	-	p
Qm M 11	2:1	s	g	-	p
Qm M 12	2.5:1	s,b	g	-	d

Table 3. Anomalous features of Canyon Oaks Occurring on Suspected Parent Species

Species	<i>Q. gambelii</i>	<i>Q. havardii</i>	<i>Q. macrocarpa</i>	<i>Q. stellata</i>
Anomalous feature	Lobing; Stipules; Pubescence	None	Lobing; Stipules; Trichomes; Vena- tion; Pubescence	Pubescence; Trichomes
Number	3	0	5	2

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Table 4. Aberrant Feature Occurrence on Cinnamon Canyon Oaks.  
 Legend: X=presence of feature, - = absence of feature

Specimen	Aberrant Features					Number of Features
	Lobing	Stipules	Trichomes	Venation	Pubescence	
Qm C 1	X	-	X	X	-	3
Qm C 2	-	X	X	X	X	4
Qm C 3	X	-	X	-	-	2
Qm C 4	X	-	X	-	-	2
Qm C 5	X	-	X	-	-	2
Qm C 6	-	X	X	-	X	3
Qm C 7	-	X	X	X	-	3
Qm C 8	X	X	X	-	X	4
Qm C 9	X	X	X	-	-	3
Qm C 10	-	-	X	-	-	1
Qm C 11	X	-	X	-	-	2
Qm C 12	X	-	X	-	-	2
Total Occurrences	8	5	12	3	3	31

Table 5. Occurrence per Specimen and Totals for Aberrant Features on Mulberry Canyon Oaks.  
 Legend: X = Presence of Feature - = Absence of Feature; B = bulbous trichomes

Specimen	Aberrant Features					Number of Features
	Lobing	Stipules	Trichomes	Venation	Pubescence	
Qm M 1	-	X	X	X	-	3
Qm M 2	-	-	-	-	-	0
Qm M 3	X	-	-	X	-	2
Qm M 4	-	-	X	X	-	2
Qm M 5	-	-	-	X	-	1
Qm M 6	-	-	-	-	-	0
Qm M 7	-	-	-	X	-	1
Qm M 8	-	-	-	-	-	0
Qm M 9	-	-	-	-	-	1
Qm M 10	X	-	-	-	-	0
Qm M 11	-	-	-	-	-	0
Qm M 12	X	-	X	X	-	3
					-	
					-	
					-	
					-	
Total Occurrences	3	1	3	6	0	13

Table 6. Occurrences per specimen and totals of aberrant features of Cinnamon Canyon Oaks

Specimen		Aberrant Features				
	Lobing	Stipules	Trichomes	Venation	Pubescence	Number of Features
Qm 1	X	-	X B	X	-	3
Qm 2	-	X	X B	X	X	4
Qm 3	X	-	X	-	-	2
Qm 4	X	-	X	-	-	2
Qm 5	X	-	X	-		2
Qm 6	-	X	X	-	X	3
Qm 7	-	X	X	X	-	3
Qm 8	X	X	X	-	X	4
Qm 9	X	X	X	-	-	3
Qm 10	-	-	X	-	-	1
Qm 11	X	-	X	-	-	2
Qm 12	X	-	X B	-	-	2
Total Occurrences	8	5	12	3	3	31

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Of the species considered as the possible source of the features, only Bur Oak has the constellation of characters found among the Canyon Oaks. Especially convincing is the occurrence of *Q. macrocarpa*-like fasciculate trichomes on many of the specimens. However, with respect to trichome types and their occurrence on *Q. muehlenbergii*, my interpretation differs from that of Hardin (1979). His Atlas includes the fasciculate type for *Q. muehlenbergii* whereas I believe they are atypical. Both from field and herbarium studies, I have found when leaves of *Q. muehlenbergii* produce fasciculate hairs there is a correspondence in range and average for quantitative features, i.e., number of rays and spread, to those of *Q. macrocarpa*. A wide leaf form of *Q. muehlenbergii*, *f. alexanderi* Britton, frequently has only the fasciculate trichomes, a condition also sometimes observed in *Q. macrocarpa* Thomson (1979). For this study I have taken the position that fasciculate trichomes are not typical for *Q. muehlenbergii* and their presence adds to the evidence of hybridization.

Taking this position does increase the number of characters and occurrences used to support hybridization. However, if occurrence of fasciculate trichomes is excluded from the analysis, there is still strong support for the plants' hybrid origin as 13 specimens displayed an indentation index above 2.1:1, nine showed the divergent venation pattern, six possessed terminal bud stipules, six produced bulbous trichomes and three had persistent pubescence, Tables 1 and 2.

Of the others, Post oak and Havard Oak are known to occur in the preserve but not Gambel's Oak or Bur Oak. Havard Oak was rejected as a possible second parent as its characteristics are not consistent with it being a partner in introgression.

Post Oak does have twigs that remain pubescent and its trichomes include the bulbous type, but it was also rejected as the parent because its terminal buds do not bear stipules, and its leaves do not have a vein pattern found in some of the suspected hybrids. Also, its stel-

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late trichomes are non-appressed, often attached to pedestals, and its largest lobes are most often found in the mid or upper half of the leaf.

None of the suspected hybrids displayed the diagnostic features of *Q. gambelii*, twigs with transverse fissures and fasciculate trichomes with 1-4 rays, it was rejected as a possible second parent,

If Bur Oak, *Q. macrocarpa*, is the second parent, then this leaves the matter of how and when the pollination may have occurred. In Oklahoma, Bur Oak is widespread but is at the limit of its range in Ellis County. The single record from Turkey Creek is northeast and downwind of the Canyons making them the unlikely pollinators.

For populations of supposed hybrids of *Q. gambelii* and *Q. macrocarpa* occurring in New Mexico and South Dakota, Maze (1968) postulated a more western and northern distribution for Bur Oak during the Pleistocene. This, he posited, allowed them to become sympatric with Gambel's Oak and hybridization and introgression to occur. But the Pliocene precedes the Pleistocene, a time of separation for what would become the modern forests east and west of the Great Plains. Maze further posited that hybrids bearing features of *Q. gambelii* and *Q. macrocarpa* in areas where neither is extant, and geology dating to the Pleistocene, were likely the result of secondary contact during pluvial periods. As the climate became drier again, the hybrids survived but not the parents.

A specimen collected by Waterfall (7950 BRIT) from Cimarron County, which I believe is *Q. gambelii* × *Q. macrocarpa*, was examined during a study of *Q. gambelii* in Oklahoma, Thomson (2025), and offers further evidence of his position. Also, the soils of the site date to the Pleistocene, Johnson and Luza (2008).

Can Maze's supposition of hybridization during Pleistocene sympatry also account for the populations of introgressants in the Four Canyon Preserve? Is it plausible for Bur Oak also to have been sympatric with the Chinquapins and the fea-

tures acquired then? If so, are the Chinquapins of the Four Canyon Preserve also descendants of this time? To be sure this is speculative unless corroborated with additional evidence, but absent co-occurrence, the proposition may account for the condition of the Canyon Chinquapin Oaks.

Are all disjunct populations of *Q. muhlenbergii* Introgressants? In the 2022 study of a Chinquapin population in the Capitan Mountains, elevation 6250ft (1905m), of New Mexico, evidence of introgression by *Q. gambelii* was presented. Chinquapin oaks are not normally found in montane environments, but *Q. gambelii* is. Has the introgression allowed for adaptation to the higher elevations?

In this study I have presented evidence of introgression by *Q. macrocarpa* which I believe has contributed to the Chinquapins ability to persist in western Oklahoma. Whether all such populations are introgressants I cannot say, but it seems to be so in the ones I have studied. Perhaps further research of disjunct populations, especially with genomic testing, will add to our understanding.

The disjunct populations suggest a once more extensive range for the species, but more so to the white oak clade's capacity for adapting to changing climatic regimes, Kremer and Hipp (2019). The Chinquapins of Ellis County stand with their counterparts from the mountains of New Mexico to the arroyos of west Texas as testaments to this capability.

#### SPECIMEN AND DATA AVAILIBLTY

A set of each of the specimens used in this study were contributed to the Robert Bebb Herbarium (OKL) and the Oklahoma State University herbarium (OKLA) respectively. For information about them please contact Amy Buthod, Collections Manager (OKL) [amybuthod@ou.edu](mailto:amybuthod@ou.edu) and Mark Fishbein, Curator [mark.fishbein@okstate.edu](mailto:mark.fishbein@okstate.edu) (OKLA).

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