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Where are all of Arkansas' Chinquapins? An Ecological Assessment of Castanea Throughout the State

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Where are all of Arkansas' Chinquapins?
An Ecological Assessment of *Castanea* Throughout the State

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by

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Abstract

Around the turn of the twentieth-century, the chestnut blight fungus (*Cryphonectria parasitica*) was accidentally introduced into North America. This strong pathogen, which specializes on trees of the genus *Castanea*, spread rapidly and within half a century had nearly extirpated North America's *Castanea* natives from their ranges. During this catastrophe, the American chestnut (*Castanea dentata*) garnered much of the scientific attention, pushing the other *Castanea* natives – the chinquapins – to the wayside. More than a century following the spread of the blight, little research into the ecology of North America's chinquapins had been performed, leaving these trees significantly underrepresented. The ranges of the two native geographical varieties of chinquapin (*C. pumila* var. *pumila* and *C. pumila* var. *ozarkensis*) converge along a gradient that bisects the state of Arkansas. The objectives of this project were to (1) assess the distribution and status of *C. pumila* populations throughout Arkansas, (2) to describe and compare the ecology of each variety, and (3) to quantify and compare the vegetative morphologies of the two varieties. The results indicate that *C. pumila* populations throughout Arkansas persisted, but remained highly suppressed by the blight in both growth form and reproduction. *Castanea pumila* var. *pumila* tended to occur at lower elevations and sub-mesic sites in the Coastal Plain, whereas *C. pumila* var. *ozarkensis* tended to occur at higher elevations and steeper slopes on sub-xeric to xeric sites of the Ozark Plateau and Ouachita Mountains. In a multivariate morphometric analysis of vegetation, mature leaves of *C. pumila* var. *ozarkensis* tended to be significantly larger than those of *C. pumila* var. *pumila*, yet specimens of both varieties from Arkansas were significantly larger than *C. pumila* var. *pumila* specimens from other states. Despite leaf size differences, no significant difference was observed in leaf shape. Additionally, no significant difference in foliar vestiture was observed between varieties.

Acknowledgement

I would like to thank my advisor, Dr. Steven L. Stephenson, for all his support and guidance throughout this research. Your direction and advice were invaluable to my education and the principles you've taught me will remain with me throughout my future as an ecologist. I wish to also acknowledge the members of my graduate committee, Dr. Johnnie L. Gentry and Dr. Fred Paillet, for their knowledge and direction throughout this research and during my undergraduate education. It has been an absolute pleasure meeting and working with each of you.

Thank you to the Department of Biological Sciences for the supplies, office space, equipment, and numerous Teaching Assistant appointments throughout my time at UARK. I would especially like to acknowledge Becky Harris and Dr. Michelle Evans – White for their administrative and logistical support.

Appreciation is extended to the Arkansas Native Plant Society for speaking opportunities and funding through the Delzie Demaree Research Grant. Further, I must thank the individuals who helped with data collection and permitting throughout Arkansas – Brent Baker and Theo Witsell with the Arkansas Natural Heritage Commission, Chuck Bitting with the Buffalo National River, Dr. Karen Fawley with the University of Arkansas at Monticello Herbarium, the herbarium at the University of Arkansas, and Joe Stuckey for field site locations. I thank Marvin Estes and David Garvin for their help and comradery in the field.

A special thank you is extended to my friends and family for their unwavering support throughout this research. Thank you to my lab-mates, Eathan Gentry and Brittany Booth, for always keeping things light-hearted. Thank you to my family for support and understanding during this time. Lastly, an enormous thank you to my wife, Amber, for her support on all levels.

Dedication

I dedicate this thesis to Chloe Belle Estes. You will accomplish great things if you apply yourself, work hard, and – most importantly – chase your dreams.

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Introduction

The story of the American chestnut tree (*Castanea dentata* [Marsh.] Borkh.) could be regarded as the most catastrophic downfall of an organism in modern times. History is riddled with examples of plants and animals being driven toward and past the brink of extinction by the careless actions of humans, but few organisms as highly regarded as the American chestnut face such a fate. The American chestnut draws its iconic status from days long past when it towered over the forests of eastern North America, providing bountiful lumber and delicious fruit for many (Hepting 1974). This legendary tree met its match at the start of the twentieth century with the anthropogenic introduction of an invasive and pathogenic fungus, appropriately named the chestnut blight fungus (*Cryphonectria parasitica* [Murr.] Barr.) (Anagnostakis 1992, Rigling and Prospero 2018). Within sixty years, the blight's impact had expanded from northern New England as far west as western Arkansas, leaving a path of destruction as North America's native chestnuts were nearly extirpated (Paillet and Cerney 2012). The sudden loss of these trees set in motion widespread changes in the ecology of the forest communities they once dominated and had major social and economic impacts on the communities of people that they once supported (Elliott and Swank 2008, Holmes et al. 2009).

As the American chestnut became the poster-child of this catastrophe, garnering significant attention from both the scientific and public eyes, the other native trees in the chestnut group, the chinquapins, were largely overlooked. As sister taxa to the American chestnut, the chinquapins share many characteristics and were historically valuable for similar reasons. Chinquapins are noted for their rot resistant lumber which was ideal for fence posts and railroad ties, as well as a few medicinal properties. Most notably, chinquapins are regarded by both man and wildlife for their delicious and bountiful nut crop and have been described as the "most

mistreated and misrepresented native North American nut tree" (Payne et al. 1994). Additionally, studies have suggested that, in comparison to the American chestnut, the chinquapins have a heightened resistance to the chestnut blight fungus (Graves 1950, Chandler 1957). Despite all the beneficial qualities exhibited by North America's native chinquapins, they were largely neglected by taxonomists and biologists until the latter part of the twentieth century, which resulted in a lack of understanding in many areas of their natural histories and a muddled consensus on their taxonomic classification.

The chinquapins, which are historically known to vary significantly in physical form from understory shrubs to large single-stemmed canopy trees, exist today primarily as suppressed shoots arising from old root systems or old seedlings. Individual shoots rarely live long enough to fruit before succumbing to the blight, yet more shoots continue to grow, a characteristic that speaks to the tenacity of these hardy plants (Graves 1950). Historically, as many as 11 chinquapin taxa have been considered native to North America, eight of which were species (Sudworth 1922, Ashe 1923, 1924). With time, however, these taxa were continually combined into *Castanea pumila* (L.) Mill. based on a general lack of unique morphological characteristics and geographic intergradation (Little 1953, Tucker 1975). Many authors follow the taxonomy and nomenclature proposed by Tucker (1975), yet some noteworthy publications disagree and presently consider there to be two distinct species of chinquapin native to North America (Nixon 1997). This thesis follows the nomenclature proposed by Tucker (1975).

The Allegheny chinquapin (*Castanea pumila* [L.] Mill. var. *pumila* G. E. Tucker), is often described as a small tree or shrub to 10 meters (Strausbaugh and Core 1977, Weakley et al. 2012), and was historically known similarly as a sub-canopy tree or shrub (Paillet 1993). *Castanea pumila* var. *pumila* has the widest range of the two varieties, occurring within portions

of the Coastal Plain and Appalachian Highlands physiographic regions (Fenneman and Johnson 1948), extending from southern Pennsylvania, south to northern Florida, west to eastern Texas, and southern Arkansas (Tucker 1975, Little 1976). For reference, Figure 1 details the physiographic regions of North America as demonstrated by Fenneman and Johnson (1948), Figure 2 illustrates the recorded range of *C. pumila* var. *pumila* (Little 1976), and Figure 3 displays images of *C. pumila* var. *pumila* in the field.

The Ozark chinquapin (*Castanea pumila* [L.] Mill. var. *ozarkensis* (Ashe) G. E. Tucker) is generally considered endemic to, or at least currently geographically isolated to, the Ozark and Ouachita portions of the Interior Highlandss physiographic region (Fenneman and Johnson 1948), which extends northward from central Arkansas to extreme southern Missouri, west to eastern Oklahoma and northwest Arkansas (Tucker 1975, Little 1976, Johnson 1988). Figure 4 shows the recorded range of *C. pumila* var. *ozarkensis*. Historical records on the habit of these trees indicate that the chinquapins that occurred in the Ozarks pre-blight were canopy level trees, capable of heights nearing 20 m and diameters as great as one meter (Ashe 1923). Since the latter half of the 20th century, the suppression brought on by the blight limits most individuals of this variety to subcanopy heights, often with numerous shoots arising from a common root system, and thus the habit description of small tree or shrub is often applied (Paillet 1993, 2012, pers. obser.). Figure 5 displays images of *C. pumila* var. *ozarkensis* in the field.

A limited number of studies have set out to broadly investigate and accurately define and differentiate the morphology of North America's chinquapins, which initially yielded a baseline for comparison but also uncovered that there exists a great deal of overlap and even intergradation in morphological characteristics, especially where the respective ranges are known to converge, bringing scientists to further question their classification (Tucker 1975, Johnson

1985, 1988). The major point of convergence between the ranges of the two varieties coincides with the borders of the Interior Highlands and Atlantic Coastal Plain physiographic regions that bisects the state of Arkansas from its southwestern to northeastern corners. The land therein forms a gradient from sandy, mesic lowland habitats to xeric uplands characterized by poor soils (Fenneman and Johnson 1948). These and other factors make the forests of Arkansas highly suitable for comparative assessments on the varieties of *C. pumila*.

For that very purpose, this project took place within the political bounds of the state of Arkansas. The primary objectives were to (1) asses the state-wide population health status and geographical distribution of each variety, (2) to describe and compare the ecology and habitat preferences of each variety, and (3) to describe and compare the vegetative morphology of each variety. At the time this study was conducted, more than half a century had elapsed since the blight swept through Arkansas and killed the existing chinquapins, and yet very few studies had assessed the status of the state's *Castanea* populations, post-blight. To the author's knowledge, no work relatively close to this scale had been carried out on *Castanea* in Arkansas. The following sections describe the methods, results, and implications of the findings of numerous separate analyses and field observations made by the author in an effort to advance the understanding of these forgotten trees.

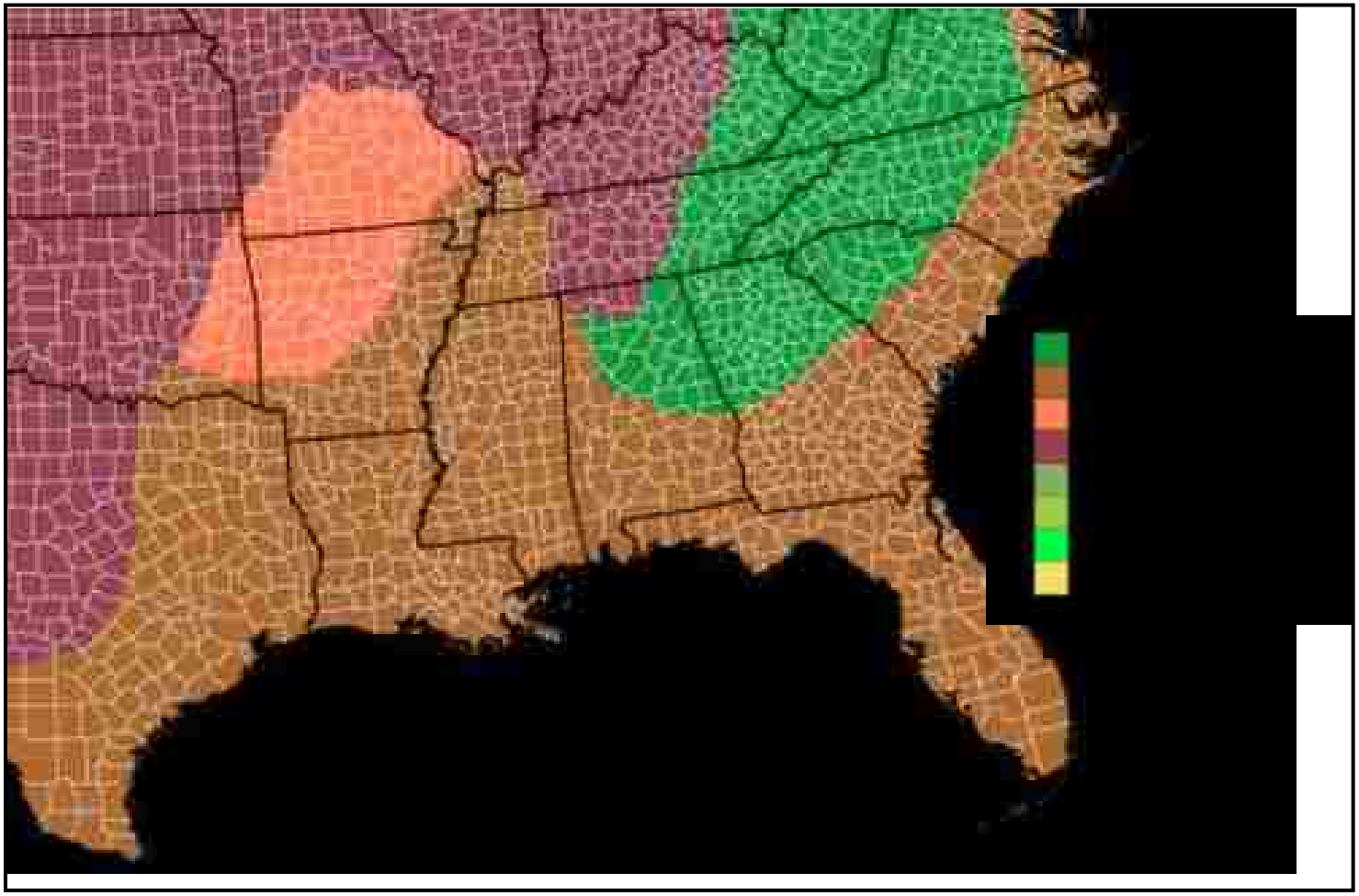


Figure 1. Major physiographic divisions of the Conterminous United States as they pertain to the southeastern states. Modified after Fenneman and Johnson (1948).

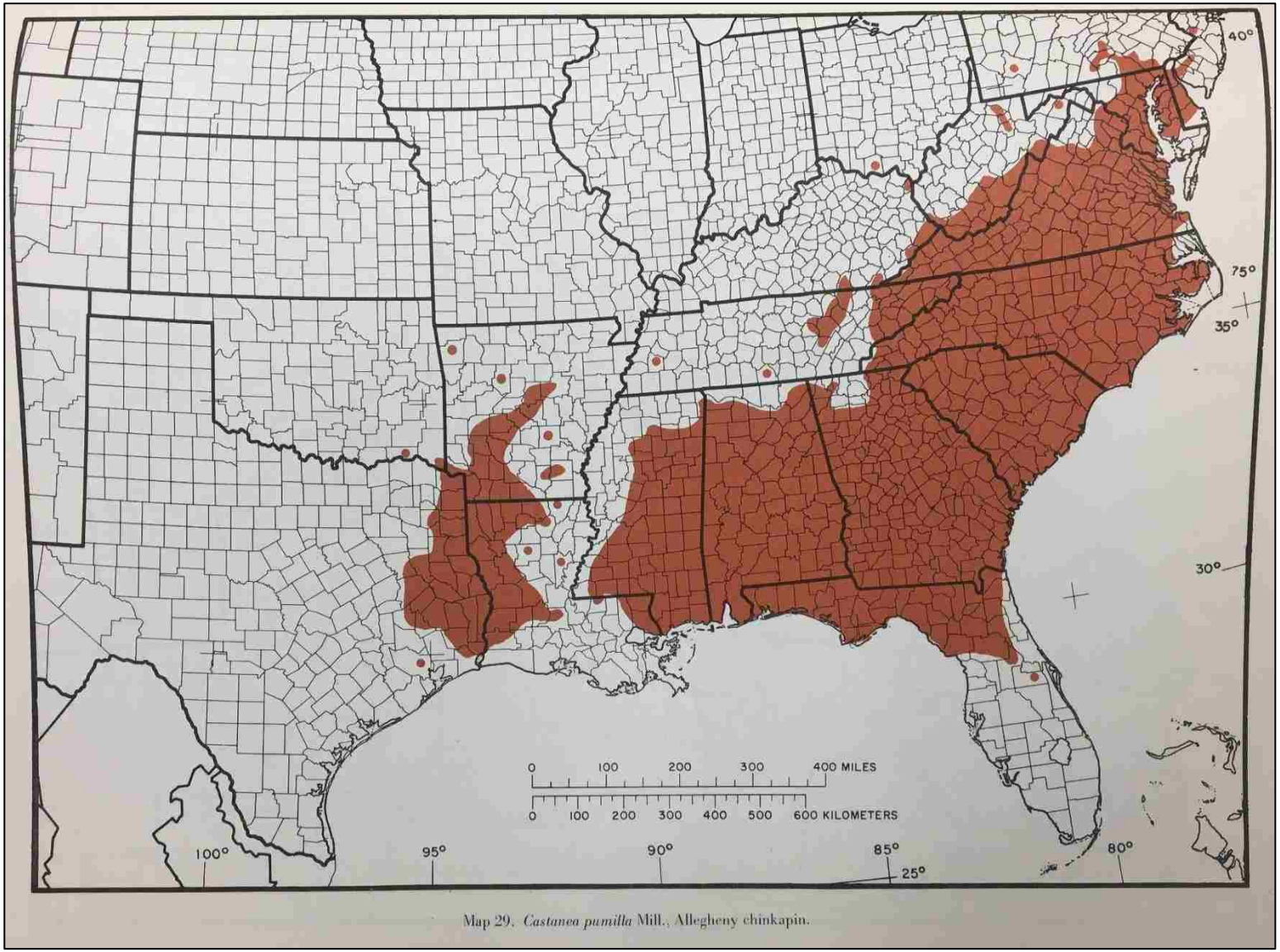


Figure 2. Range map of *Castanea pumila* (L.) Mill. var. *pumila* G. E. Tucker. After Little (1976).

Figure 3. Two clones of *C. pumila* var. *pumila* in the field. Left: As an understory shrub in an open, sub-mesic forest, Ouachita County, Arkansas. Right: Three large shoots in close proximity to one another in a light gap, sand hills of Miller County, Arkansas. (Photos by author)

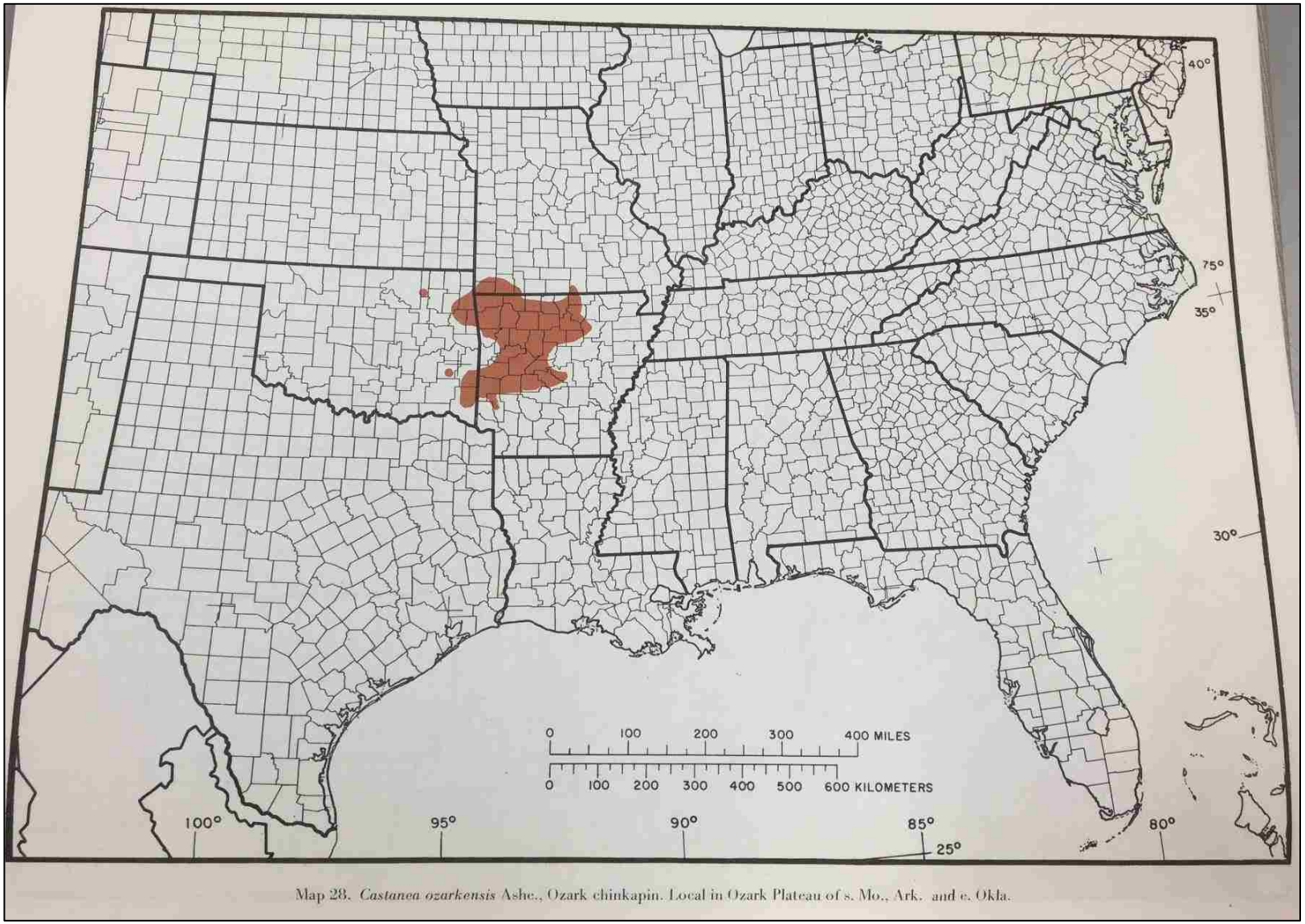


Figure 4. Range map of *Castanea pumila* (L.) Mill. var. *ozarkensis* (Ashe) G. E. Tucker. After Little (1976).

Figure 5. Two clones of *C. pumila* var. *ozarkensis* in the field. Left: Multiple shoots arising from a limestone outcropping along a xeric ridge, Izard County, Arkansas. Right: A *Castanea pumila* var. *ozarkensis* clone in an open forest in Marion County, Arkansas. Multiple young living shoots in the understory with standing dead shoots approaching the canopy. (Photos by

Materials and Methods

A. Site selection

The locations of many field sites used in this project were derived from historic observations that had been noted in herbarium records or otherwise recorded in databases that were made available to the author by their administrators. Beyond herbarium records, prospective site locations were derived from word-of-mouth recommendations and personal observations. For the purpose of clarity, a "site" as used herein is defined as any location that contained at least one individual of either variety. Some sites contained multiple individuals, while others contained only a single individual. This determination was made if there existed a measurable difference in site parameters between geographically closely adjacent individuals; if no significant difference existed, then the general location in question was considered a single site.

The initial searches for potential populations were done by reviewing herbarium specimens. One resource that proved to be particularly valuable in this pursuit was the Southeast Regional Network of Expertise and Collections' (SERNEC) online database. This resource allowed the author to search for occurrence records of *Castanea pumila var. ozarkensis* and/or *Castanea pumila var. pumila* collected in Arkansas and deposited across numerous herbaria. Additionally, Dr. Karen Fawley from the herbarium at the University of Arkansas at Monticello (UAM) sent the author several specimen photographs of their entire collection of *Castanea* from Arkansas. Specimen photographs were acquired from Brent Baker, a botanist with the Arkansas Natural Heritage Commission (ANHC). Additionally, two databases of recorded locations were shared with the author, one from Charles Bitting with the Buffalo National River (BNR), and the other from Brent Baker, ANHC.

Aside from the historical records that were provided to the author, numerous helpful word-of-mouth recommendations on the locations of potential populations from several individuals were offered. Dr. Fred Paillet from the University of Arkansas provided many locations in person, as well as through his published papers. Brent Baker and Theo Witsell from ANHC, and Joe Stuckey, a member of the Arkansas Native Plant Society (ANPS), shared directions to populations from their personal field observations as well. A few sites came from the author's personal field observations, including some that could be considered bycatch as they were happened upon while en route to preexisting sites.

Once the records were received, the specific localities were mapped for future use. For herbarium specimens, the locality data that were provided by the original collector were analyzed to decipher the general location of the referenced tree and/or population. If the general location could be determined using coordinates, section maps, road directions, or other sources of information, the potential population(s) were plotted on a virtual map using Google's MyMaps service (https://www.google.com/mymaps). The two databases contained coordinates, which were plotted directly within the map of potential occurrences. It is important to note that while hundreds of herbarium specimens were reviewed, many yielded no useable data due to imprecise locality references (e.g., only the county listed for location or vague directions such as "four miles SE of Hot Springs"). Despite this, herbarium records provided me with an initial list of numerous potential populations which, later, was significantly boosted by the addition of the database coordinates and personal observation data.

B. Field data collection

Upon finding an individual and/or clustered population in the field, data were recorded for a list of pre-determined parameters. Field data in this project can be broken into two categories, individual-specific data and site-specific data. For each individual that was located, data were recorded for the following parameters:

- **Date of observation**
- **General location** – such as the Natural Area name, etc.
- **Specific location** – GPS coordinates of the individual
- **Stem data**
    - **Number of stems** – a count of the number of stems that made up a single individual
    - **Stem health** – alive or dead
    - **Stem height** – the height of the stems from the ground to the tallest/longest point
    - **Stem DBH** – diameter at breast height. In the case of dead, broken stems, if breast height was not achieved, the diameter was taken at the highest point above the ground.
    - **Blight** – notes on any indication of infection with the chestnut blight fungus
    - **Fruit** – whether fruiting or not, or if old fruits or burs were found nearby
- **Photographs** – at least one photograph was taken of each individual, *in situ*
- **Notes** – anything of note that was not represented in the parameters listed above

For each site where an individual was located the following parameters were recorded:

- **Percent inclination** – extent of the slope's inclination – if a slope existed – using a Suunto clinometer (Suunto PM-5/360)
- **Slope azimuth** – the degree representation of compass direction of the slope
- **10 m woody plant species tally** – a tally of any woody plant species that was located within ten meters of the individual(s) at the site.
- **Photographs –** if not represented well in the individual photos, site-specific photos were taken for documentation
- **Notes** – anything of note about the site, including a general description

C. Specimen collection

At each site (where permitted), at least one vegetation voucher specimen was collected for later analysis. When possible, specimens were taken from different individuals. An ideal voucher specimen in this work was one taken from a healthy individual, from full sunlight, exhibiting minimal herbivore damage, and being roughly the size of an herbarium sheet. Notably, not all specimens exhibited these qualities fully and some were taken anyway because they were the closest option that existed within the site. Upon collection, specimens were tagged with their corresponding number, collection date, and location data, and were then arranged and placed into a plant press for drying and preservation. Upon completion of this project, the specimens are to be mounted and deposited in the herbarium of the University of Arkansas (UARK).

D. Taxonomic identification

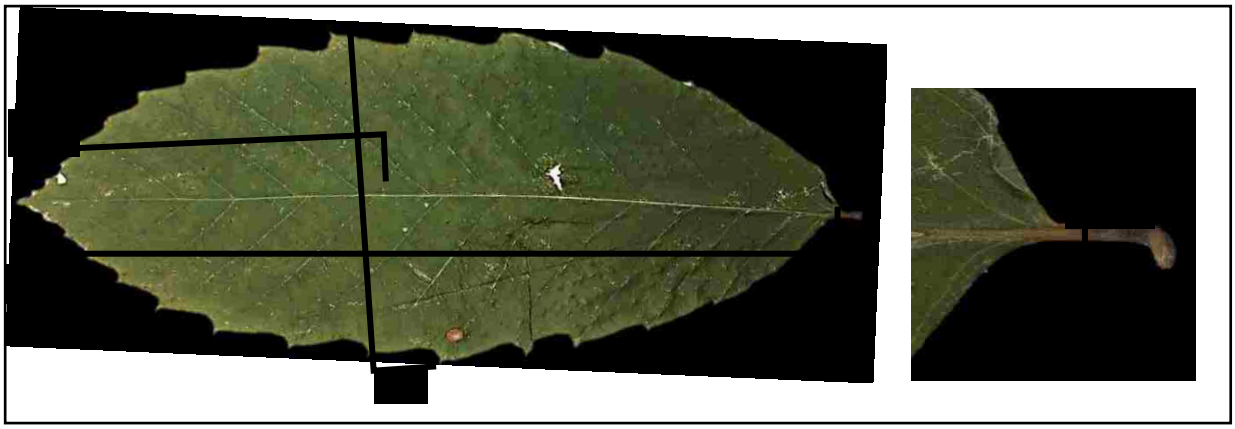
Taxonomic identification of each clone/population was derived using a combination of historical records, field observations, and voucher specimen morphology. The historical occurrence data that existed for each site provided a preliminary identification of the chinquapin clone(s) observed during this project. Considering the taxonomic reviews and edits that had been made throughout time to many of the herbarium specimens utilized for this project by G.P. Johnson and others, the author was confident that the historically noted populations were identified correctly. Each site was visited with the historic determination(s) in mind. The final determination of each population in this project was based upon the historical identifications, the observed field parameters (habitat type, geographic locality, physical growth form, coarse woody debris representing relic logs, etc.), and the morphology of voucher specimens collected. For the sites that represented intermediates based upon habitat and geographic location, the observed vegetative morphology was considered more strongly for the identification.

E. Multivariate morphometric vegetation analysis

The leaves of each voucher specimen collected from one of this project's field sites were subjected to several measurements to quantify and compare the vegetative morphology of the two varieties. The goal of this analysis was to generate the most data possible by measuring every leaf that was deemed measurable for a high-volume dataset of vegetative morphological characteristics. In this analysis, a leaf from one of the voucher specimens was considered measurable if and only if it met each of the following conditions – leaf was mature, leaf apex present, margins at widest point of leaf blade intact, leaf base intact, basal-most teeth intact. With these strict conditions upheld, not all the leaves of every specimen were measurable due to damage from herbivory, or other reasons. For every leaf that met the full conditions for

measurement, the following measurements were taken using a digital caliper accurate to 0.01 mm (Pittsburgh tools # 63713). Figure 6 displays these measurements as they were taken.

- **Blade length** – leaf blade length from base to apex
- **Blade width at widest point** – leaf blade width at its widest point, perpendicular to the midrib, often at the tips of a set of margin teeth
- **Widest point (from tip)** – where the widest point of the blade occurred along the leaf's length, measured from the tip
- **Petiole length –** length of the petiole from the point it joins the twig to the base of the leaf blade
- **Petiole diameter** – the diameter of the petiole at or as close as possible to the midpoint of its length
- **Number of teeth left side** – a tally of the teeth on the left side of the leaf blade
- **Number of teeth right side** – a tally of the teeth on the right side of the leaf blade



Once the above vegetation measurements were taken, these data were managed with Microsoft Excel, where several other calculations were derived. The following calculations were derived within Excel from the hand-measured data:

- **Leaf total length** – the total length of the leaf, equal to the sum of the blade length and the petiole length
- **Percent of leaf: blade** – the percent of the leaf's total length that was represented by the blade, equal to ((blade length/ leaf total length) x 100)
- **Percent of leaf: petiole** – the percent of the leaf's total length that was represented by the petiole, equal to ((petiole length/ leaf total length) x 100)
- **Widest point (from base)** – equal to total blade length – widest point from tip
- **Widest point percent (from tip)** – the percent of the total leaf blade length at which the widest point occurred, equal to ((widest point from tip / total leaf length) x 100)
- **Mean number of teeth per side** – the mean number of teeth on one margin of the leaf, equal to ((# of teeth R side + # teeth L side)/2)
- **Mean number of teeth/ cm blade length** – the mean number of teeth per centimeter of blade length, equal to (mean number of teeth per side/ leaf blade length)

1. Herbarium Specimen Loan

To better compare *Castanea pumila* var. *ozarkensis* to *Castanea pumila* var. *pumila* from Arkansas, where the respective ranges of the two varieties are considered to overlap, the author was advised to seek an herbarium loan of *C. pumila* var. *pumila* specimens that were collected far from the study area in question. A loan of ten *C. pumila* var. *pumila* specimens from the herbarium at Virginia Polytechnic Institute and State University were utilized. These specimens were collected from Virginia, West Virginia, North Carolina, and Tennessee. These specimens

were subjected to the same morphometric analyses as were the specimens collected by the author, and the data were compared to the Arkansas specimens of each variety.

2. Single-tree vegetative morphology analysis

To better understand the potential variation that may exist within the vegetation occurring at different heights, sun exposures, etc., a set of collections was made from a single tree that experienced a wide array of light exposures at any given time. The tree used was a *Castanea pumila* var. *ozarkensis* with a height greater than ten meters and was located on the Estes farm in Boone County, Arkansas. A total of six specimens were collected on a single day from this tree, in sets of two. The first set was collected from limbs approximately three meters from the ground, which were suspected to receive shade most of the day, and very little direct sunlight. The next pair of specimens was collected from limbs at a height of three meters where direct sunlight may have been able to permeate the canopy for short periods of time, but ultimately most of the light was diffused by the canopy above. The final pair of specimens was collected from a height of nine meters and were chosen because they appeared to receive the longest period of direct sunlight of any leaves on the target tree. These six specimens were subjected to the same morpho-metric analysis as the other specimens, however, this data was only used for comparison within this single-tree analysis in an effort to quantify the morphological differences that come with varying sun exposure.

3. Microscopic anatomy

Each voucher specimen that was collected was subjected to analyses under a microscope to investigate the type, density, and distribution of trichomes that occurred on the adaxial and abaxial leaf surfaces, leaf margins, petioles, and twigs. The stereomicroscope used was a Nikon SMZ645 paired with a Nikon NI-150 illuminator (Nikon Instruments Inc., Tokyo, Japan). The observed trichome characteristics were noted and managed with a database using Microsoft Excel for later comparison between and within varieties.

4. Statistical analyses

Data analyses to determine statistical significance were performed on all numerical data that were being compared. These data included – site ecology parameters, individual and stem data parameters, and the vegetative morphology metrics. Using the "Analysis ToolPak" add-in within Microsoft Excel, the full sample size of data for each of the above parameters were subjected to a separate single-factor analysis of variance (ANOVA) using an alpha (α) of 0.05 to determine the p-value of each group of samples. Upon testing variance, determinations were made as to whether the within-group and between-group variance(s) of the sample were statistically significant. If, and only if, a sample yielded a p-value that was less than the alpha value ($\alpha = 0.05$ in all cases), the sample was deemed statistically significant.

Results

A. *Castanea pumila* distribution in Arkansas

1. Prospective occurrence

Data compiled from herbaria, agency databases, and word-of-mouth reports were used to predict prospective distribution based on noted historical occurrence. A total of 174 prospective locations of occurrence were extrapolated for *C. pumila* var. *ozarkensis* and 43 prospective locations for *C. pumila* var. *pumila*. These prospective occurrence locations are represented in Figure 7.

2. Observations of occurrence

Castanea pumila var. *pumila* and *C. pumila* var. *ozarkensis* were observed in a total of 20 counties throughout Arkansas. Of the observations made during this project, no instance of co-occurrence within the same county was noted for the two varieties. *Castanea pumila* var. *pumila* was observed in five counties, whereas *C. pumila* var. *ozarkensis* was observed in 15 counties. All the noted observations of *C. pumila* var. *pumila* occurred farther south than the southernmost observation of *C. pumila* var. *ozarkensis*. The site location and county occurrence data are listed within Table 1.

3. Field sites

Field sites were established at suitable points of occurrence for each variety. A total of 53 field sites were designated for *C. pumila* var. *ozarkensis* and a total of nine field sites for *C. pumila* var. *pumila*. At the nine total sites for *C. pumila* var. *pumila*, a total of 20 individual clones were observed. Comparatively, a total number of 65 individual *C. pumila* var. *ozarkensis*

clones were observed for that variety's 53 total sites. Figures 8, 9, and 10 show the distribution of the field sites used for this project.

B. Site ecology and habitat preference

At each observed occurrence of *C. pumila* in this project, the following parameters were noted – elevation, slope azimuth, and percent inclination of slope. The results of these parameters are described below and listed in Table 1. Additionally, at each site of occurrence, each woody plant taxa occurring within 10 m of an individual chinquapin clone was tallied. Figures 11, 12, and 13 represent the woody plant associations for each *C. pumila* var. *pumila* site, each *C. pumila* var. *ozarkensis* site, and for taxa shared between both types of sites, respectively.

1. Elevation

The elevations for both *C. pumila* var. *pumila* and *C. pumila* var. *ozarkensis* sites were recorded in meters (m) above sea level. Sites of *C. pumila* var. *pumila* were observed at elevations ranging from 50 m to 104 m, with a mean elevation across all sites of 76 m. Sites of *C. pumila* var. *ozarkensis* were observed at elevations ranging from 84 m to 650 m with a mean elevation of 344 m. The differences observed in elevations between varieties was determined to be statistically significant, as evidenced by a p-value of 1.2928E-12. These data are presented in Figure 14.

2. Slope azimuth

Slope azimuth was noted at each site for both varieties and was recorded in degrees. The sites of *C. pumila* var. *pumila* that had a measurable slope (7 of 9 sites), had a mean slope azimuth of 122 degrees, and the sites of *C. pumila* var. *ozarkensis* that exhibited a measurable

slope (51 of 53) had a mean slope azimuth of 173 degrees. As noted above, a total of two sites for each variety exhibited no measurable slope. The differences in slope azimuth between the two varieties were not found to be statistically significant, as evidenced by a p-value of 0.12316. These data are presented in Figure 15.

3. Percent inclination of slope

Percent inclination of slope was noted at each site for both varieties and was recorded in percent. The sites of *C. pumila* var. *pumila* that had a measurable slope (7 of 9 sites), had a mean inclination of approximately 18%, and the sites of *C. pumila* var. *ozarkensis* that exhibited a measurable slope (51 of 53) had a mean percent inclination of approximately 30%. As noted above, a total of two sites for each variety exhibited no measurable slope. The differences in percent inclination between the two varieties were not found to be statistically significant, as evidenced by a p-value of 0.08378. These data are presented in Figure 16.

4. Woody plant associations

Any woody plant occurring within 10 m. of a chinquapin clone was identified (to at least the genus level) and was noted at each site for both varieties. A total of 56 woody plant taxa were observed within this proximity to a clone in this study. A total of 33 taxa were observed within a 10 m radius of *C. pumila* var. *pumila* clones (Figure 11) and a total of 43 taxa for *C. pumila* var. *ozarkensis* clones (Figure 12). Of these, a total of 12 taxa were unique to *C. pumila* var. *pumila* sites, a total of 23 taxa were unique to *C. pumila* var. *ozarkensis* sites, and 21 taxa were noted to have occurred along with both varieties (Figure 13). Clones of *C. pumila* var. *pumila* had a mean number of 10 woody plant taxa within a 10 m radius, ranging from 5 to 14 taxa at single locations, whereas clones of *C. pumila* var. *ozarkensis* clones had a mean number of 7 woody

plant taxa within this proximity, ranging from 4 to 17 taxa present at single locations. Raw data on woody plant associations for each variety are listed in Appendix F.

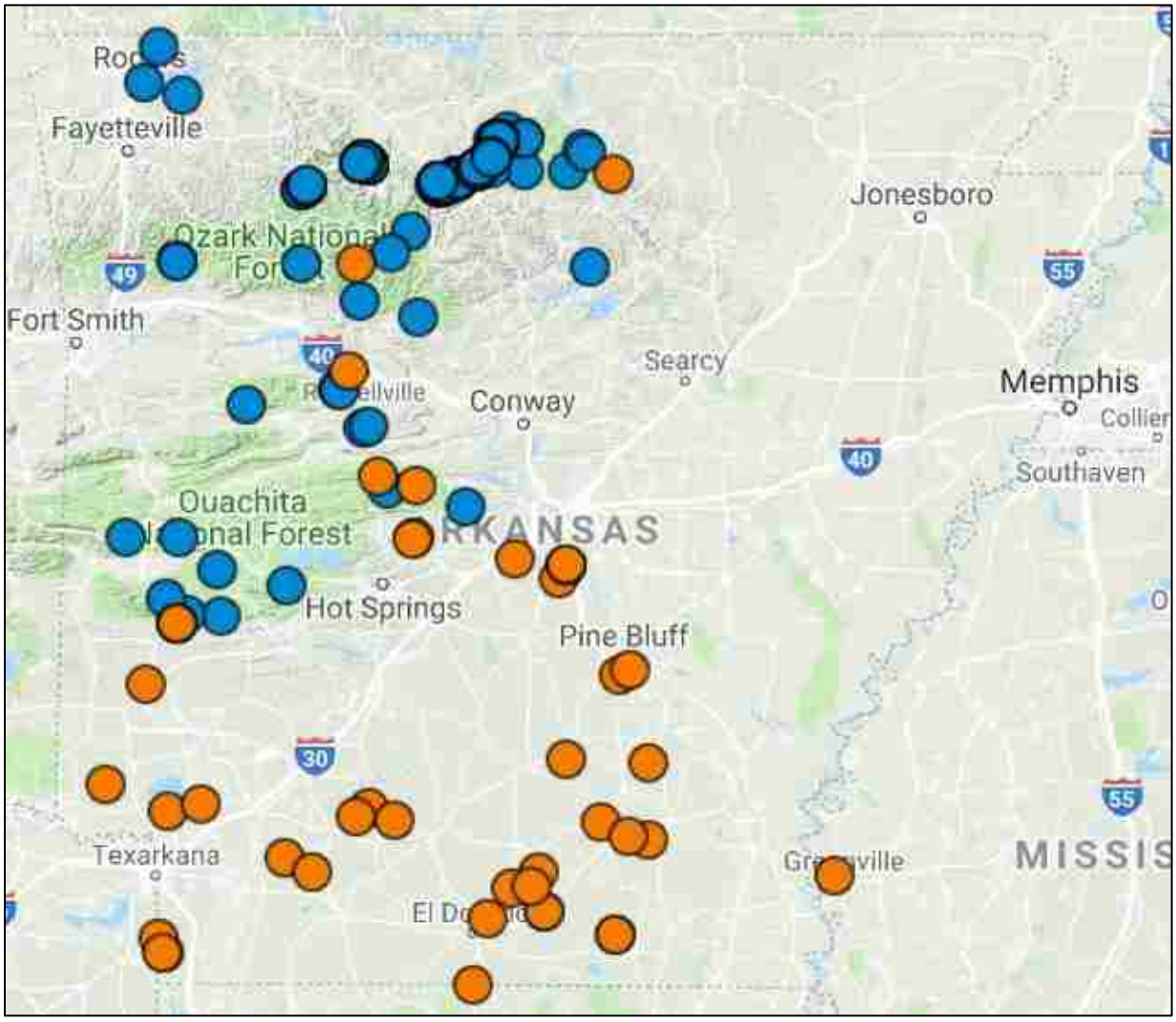


Figure 7. Locations of historic occurrences in Arkansas for each variety. Blue dots = *C. pumila* var. *ozarkensis*, n = 175. Orange dots = *C. pumila* var. *pumila*, n = 43.

Table 1. Site location and site ecology data for all field sites used in this project.

***Castanea pumila* variety**	**Site name**	**Location**	**County**	**Date**	**Elevation (m)**	**Slope azimuth (°)**	**Inclination (%)**
ozarkensis	1	34.36881, -93.9575	Polk	6/1/2017	598	140	55
ozarkensis	2	34.36876, -93.95745	Polk	6/1/2017	594	140	100
ozarkensis	10	34.67985, -94.18316	Polk	6/7/2017	445	20	7
ozarkensis	11	34.68797, -93.9492	Scott	6/12/2017	592	230	20
ozarkensis	12	34.39883, -93.76466	Montgomery	6/13/2017	490	10	45
ozarkensis	13	34.86353, -93.03443	Perry	6/13/2017	173	N/a	0
ozarkensis	14	34.86213, -92.80821	Perry	6/14/2017	356	210	13
ozarkensis	15	34.86212, -92.80812	Perry	6/14/2017	348	210	20
ozarkensis	17	36.10195, -92.18412	Stone	6/21/2017	169	0	100
ozarkensis	18	35.975, -92.22187	Stone	6/22/2017	293	80	6
ozarkensis	19	36.00602, -92.28023	Stone	6/22/2017	330	No slope	0
ozarkensis	20	36.02967, -92.43263	Searcy	6/22/2017	318	160	20
ozarkensis	21	36.12615, -92.54935	Marion	6/27/2017	166	110	50
ozarkensis	22	36.13139, -92.54755	Marion	6/27/2017	164	70	7
ozarkensis	23	36.13139, -92.54755	Marion	6/27/2017	164	70	7
ozarkensis	24	36.03472, -92.63351	Searcy	6/27/2017	213	340	42
ozarkensis	25	36.07045, -92.57885	Marion	6/27/2017	180	50	47
ozarkensis	26	36.02918, -92.57656	Searcy	6/27/2017	256	335	5
ozarkensis	27	35.96621, -92.79984	Searcy	6/28/2017	232	230	33
ozarkensis	28	35.98701, -92.7315	Searcy	6/28/2017	308	355	15
ozarkensis	29	35.96573, -93.38847	Newton	7/11/2017	450	310	23
ozarkensis	30	36.0507, -93.27435	Newton	7/11/2017	392	No data	n/a
ozarkensis	31	36.06023, -93.14145	Newton	7/11/2017	253	310	50
ozarkensis	32	36.33765, -94.09773	Benton	7/20/2017	363	355	6
ozarkensis	33	35.70231, -93.95986	Franklin	7/18/2017	628	70	100
ozarkensis	34	35.69817, -93.96098	Franklin	7/18/2017	650	180	48
ozarkensis	35	35.71488, -93.01973	Pope	7/12/2017	556	140	6
ozarkensis	36	35.97812, -92.77153	Searcy	6/28/2017	267	285	47
ozarkensis	2018 - 10	34.60616, -92.48378	Saline	7/12/2018	118	75	7

Table 1. Continued.

Castanea pumila variety	Site name	Location	County	Date	Elevation (m)	Slope azimuth (°)	Inclination (%)
ozarkensis	2018 - 11	34.58644, -92.25388	Pulaski	7/12/2018	84	240	3
ozarkensis	2018 - 12	34.58658, -92.254	Pulaski	7/12/2018	84	230	5
ozarkensis	2018 - 13	34.58642, -92.25394	Pulaski	7/12/2018	85	220	6
ozarkensis	DBNA1	36.00521, -92.04791	Izard	6/21/2017	283	10	15
ozarkensis	DBNA2	36.00514, -92.04797	Izard	6/21/2017	281	10	100
ozarkensis	HSP1	36.29132, -93.93077	Benton	10/17/2016	420	310	10
ozarkensis	HSP10	36.2984, -93.93305	Benton	10/17/2016	371	200	58
ozarkensis	HSP11	36.29851, -93.9335	Benton	10/17/2016	369	190	51
ozarkensis	HSP12	36.29852, -93.93384	Benton	10/17/2016	369	15	43
ozarkensis	HSP13	36.2985, -93.93382	Benton	10/17/2016	370	15	43
ozarkensis	HSP14	36.29849, -93.93377	Benton	10/17/2016	370	15	43
ozarkensis	HSP15	36.29845, -93.93379	Benton	10/17/2016	371	15	43
ozarkensis	HSP16	36.29847, -93.93384	Benton	10/17/2016	369	15	43
ozarkensis	HSP17	36.29903, -93.93467	Benton	10/17/2016	362	40	40
ozarkensis	HSP18	36.3018, -93.93674	Benton	10/17/2016	345	85	12
ozarkensis	HSP2	36.29037, -93.93081	Benton	10/17/2016	411	310	10
ozarkensis	HSP3	36.29252, -93.93115	Benton	10/17/2016	408	280	29
ozarkensis	HSP4	36.29256, -93.93119	Benton	10/17/2016	407	350	4
ozarkensis	HSP5	36.29309, -93.93098	Benton	10/17/2016	405	310	11
ozarkensis	HSP6	36.29374, -93.93115	Benton	10/17/2016	407	240	15
ozarkensis	HSP7	36.29407, -93.93095	Benton	10/17/2016	410	265	3
ozarkensis	HSP8	36.29534, -93.93089	Benton	10/17/2016	403	325	13
ozarkensis	HSP9	36.29694, -93.9314	Benton	10/17/2016	388	210	33
ozarkensis	WSSP	36.15859, -93.72916	Madison	10/7/2016	403	288	21

Table 1. Continued.

***Castanea pumila* variety**	**Site name**	**Location**	**County**	**Date**	**Elevation (m)**	**Slope azimuth (°)**	**Inclination (%)**
pumila	3	33.14917, -94.02227	Miller	6/6/2017	104	No slope	0
pumila	4	33.19916, -94.03618	Miller	6/6/2017	97	No slope	0
pumila	5	33.64007, -93.00535	Ouachita	6/7/2017	74	290	13
pumila	6	33.64059, -93.00566	Ouachita	6/7/2017	62	275	20
pumila	7	33.64066, -93.00584	Ouachita	6/7/2017	59	275	20
pumila	8	33.64078, -93.00582	Ouachita	6/7/2017	59	275	20
pumila	9	33.64078, -93.00582	Ouachita	6/7/2017	59	275	20
pumila	2018 - 1	33.44657, -93.36784	Nevada	7/11/2018	87	25	12
pumila	2018 - 2	33.44636, -93.3675	Nevada	7/11/2018	86	25	12
pumila	2018 - 3	33.44635, -93.3675	Nevada	7/11/2018	86	25	12
pumila	2018 - 4	33.44622, -93.36737	Nevada	7/11/2018	86	30	10
pumila	2018 - 5	33.44625, -93.36747	Nevada	7/11/2018	86	30	10
pumila	2018 - 6	33.44622, -93.36751	Nevada	7/11/2018	86	25	10
pumila	2018 - 7	33.44625, -93.3675	Nevada	7/11/2018	86	25	8
pumila	2018 - 8	33.44607, -93.36742	Nevada	7/11/2018	87	25	8
pumila	2018 - 9	33.65828, -93.16958	Nevada	7/11/2018	81	60	11
pumila	2018 - 14	33.63437, -92.10161	Bradley	7/17/2018	60	60	65
pumila	2018 - 15	33.63407, -92.10121	Bradley	7/17/2018	61	45	60
pumila	2018 - 16	33.63528, -92.1007	Bradley	7/17/2018	61	310	48
pumila	2018 - 17	33.27421, -92.60142	Union	7/18/2018	50	125	No data

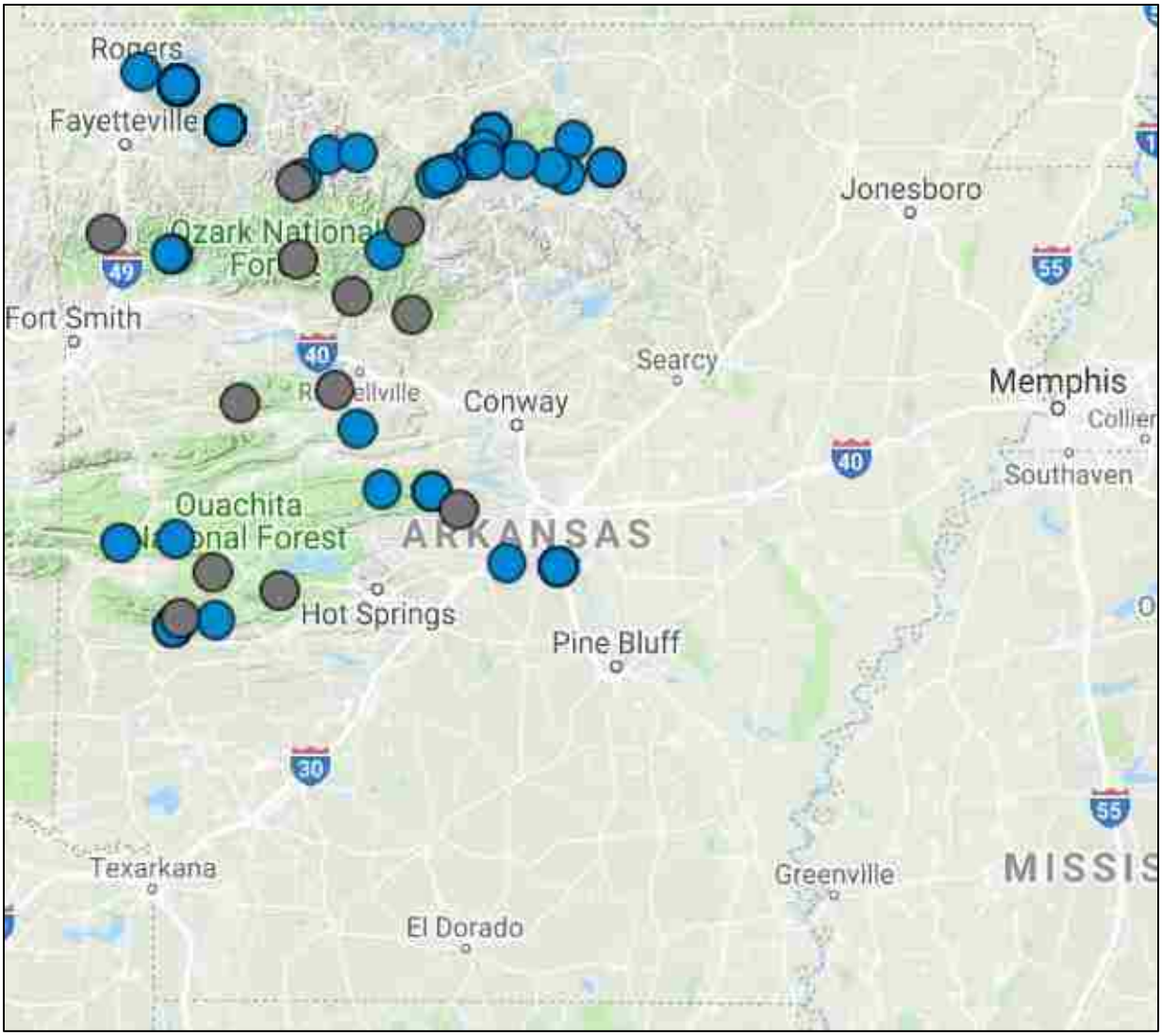


Figure 8. Locations of historical observations of occurrences of *C. pumila* var. *ozarkensis*. Blue dots = Sites where occurrence of *C. pumila* var. *ozarkensis* was observed. Gray dots = locations where the author was unable to locate any *C. pumila* var. *ozarkensis* despite historically noted occurrence.

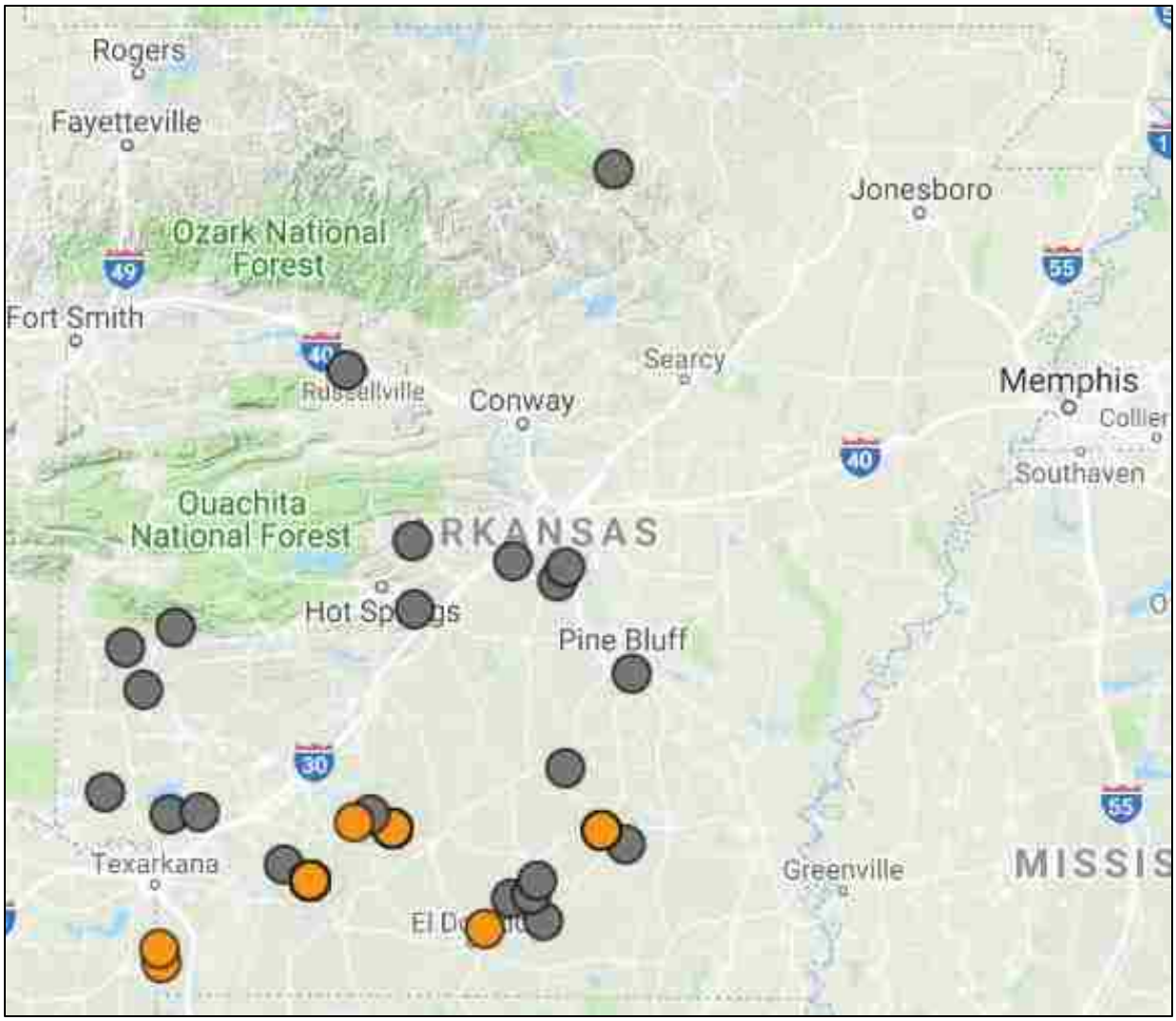


Figure 9. Locations of historical observations of occurrences of *C. pumila* var. *pumila*. Orange dots = Sites where occurrence of *C. pumila* var. *pumila* was observed. Gray dots = locations where the author was unable to locate any *C. pumila* var. *pumila* despite historically noted occurrence.

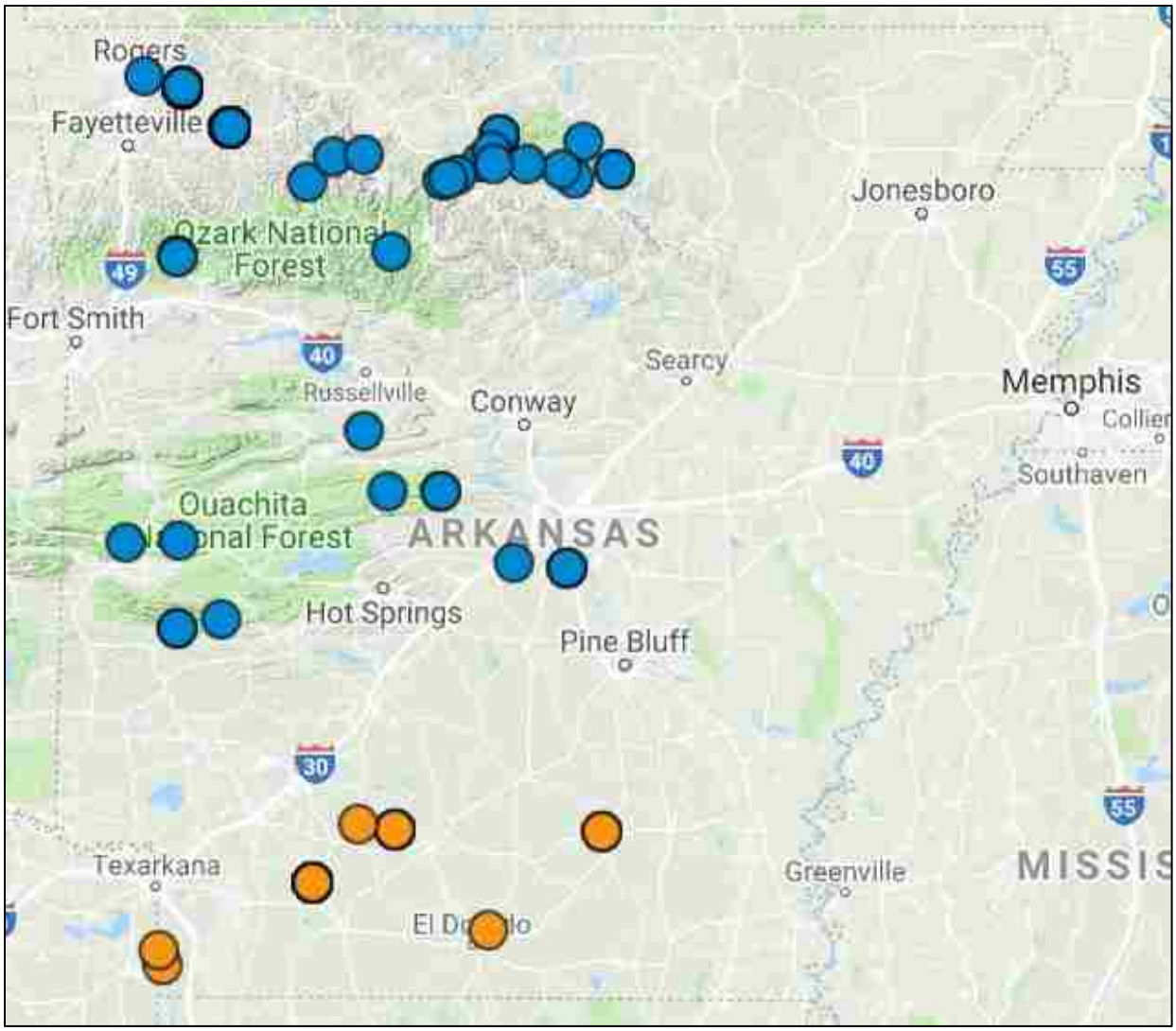


Figure 10. Locations of field sites used in this project. Blue dots = *C. pumila* var. *ozarkensis* sites, n = 53. Orange dots = *C. pumila* var. *pumila* sites, n = 9.

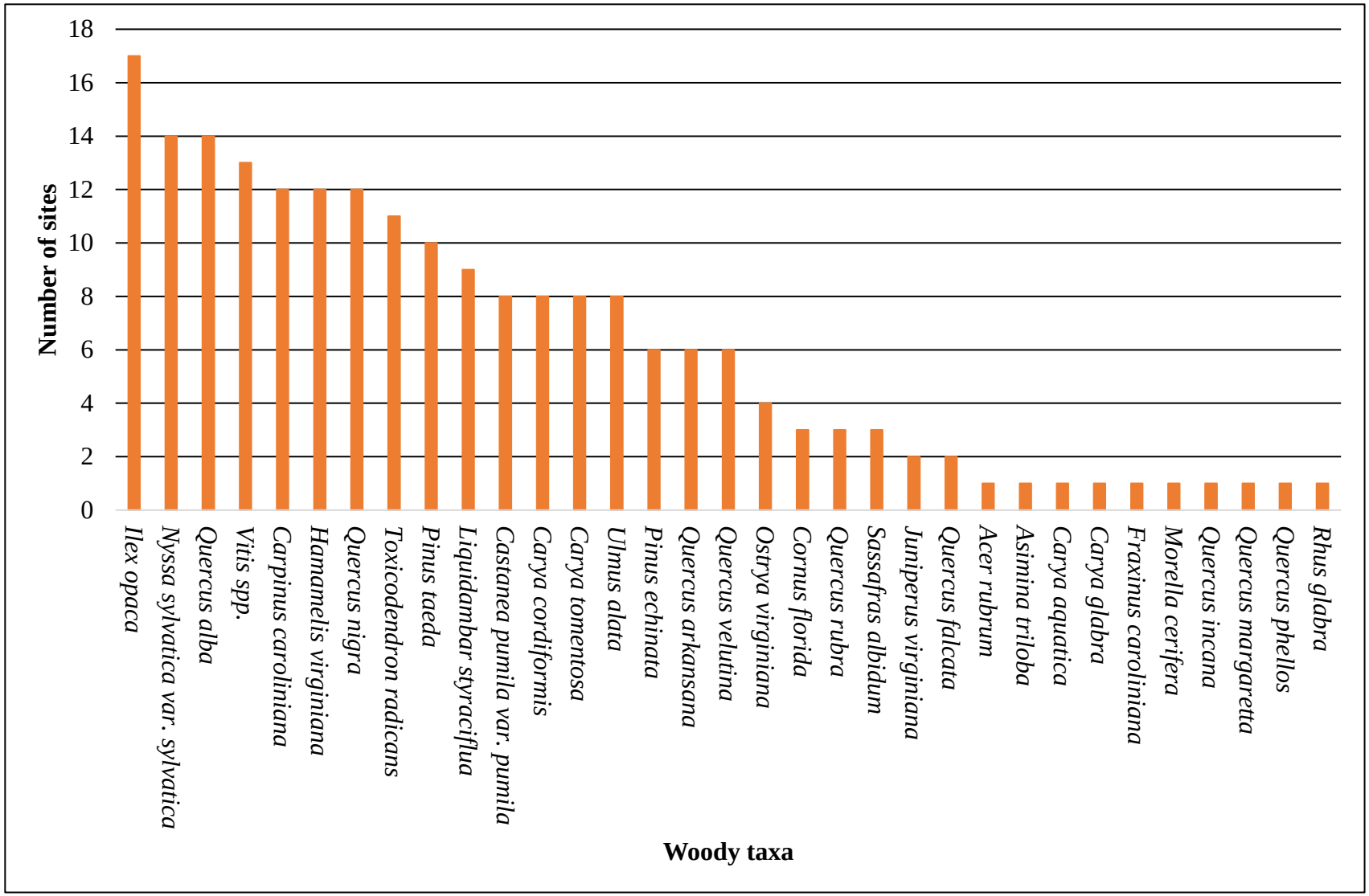


Figure 11. Frequency of occurrence of woody plant taxa located within 10 m of a clone at *Castanea pumila* var. *pumila* sites. A total of 33 taxa occurred across 9 total sites for this variety. Nomenclature follows Gentry et al. (2013).

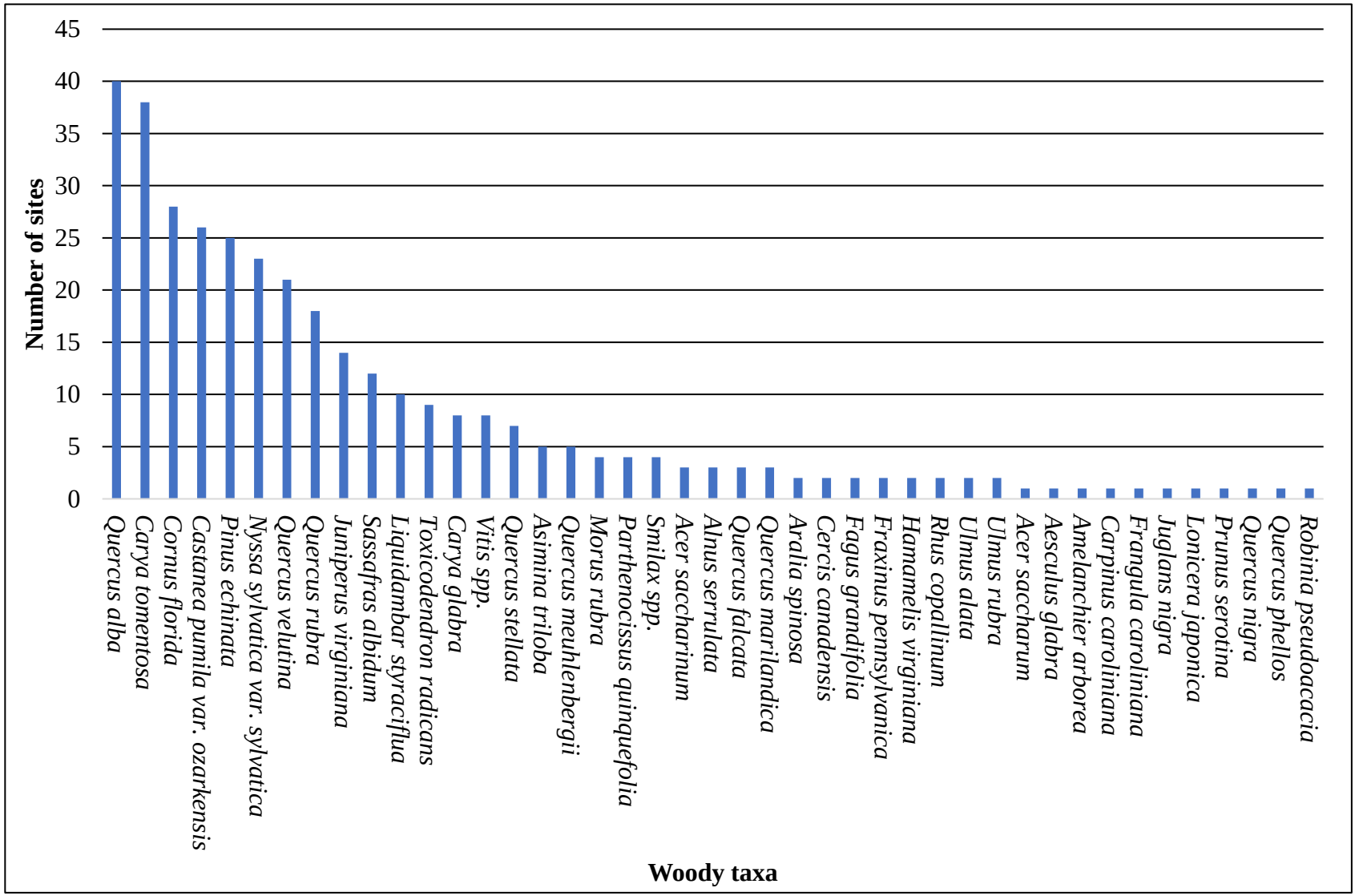


Figure 12. Frequency of occurrence of woody plant taxa located within 10 m of a clone at *Castanea pumila* var. *ozarkensis* sites. A total of 43 taxa occurred across 53 total sites for this variety. Nomenclature follows Gentry et al. (2013).

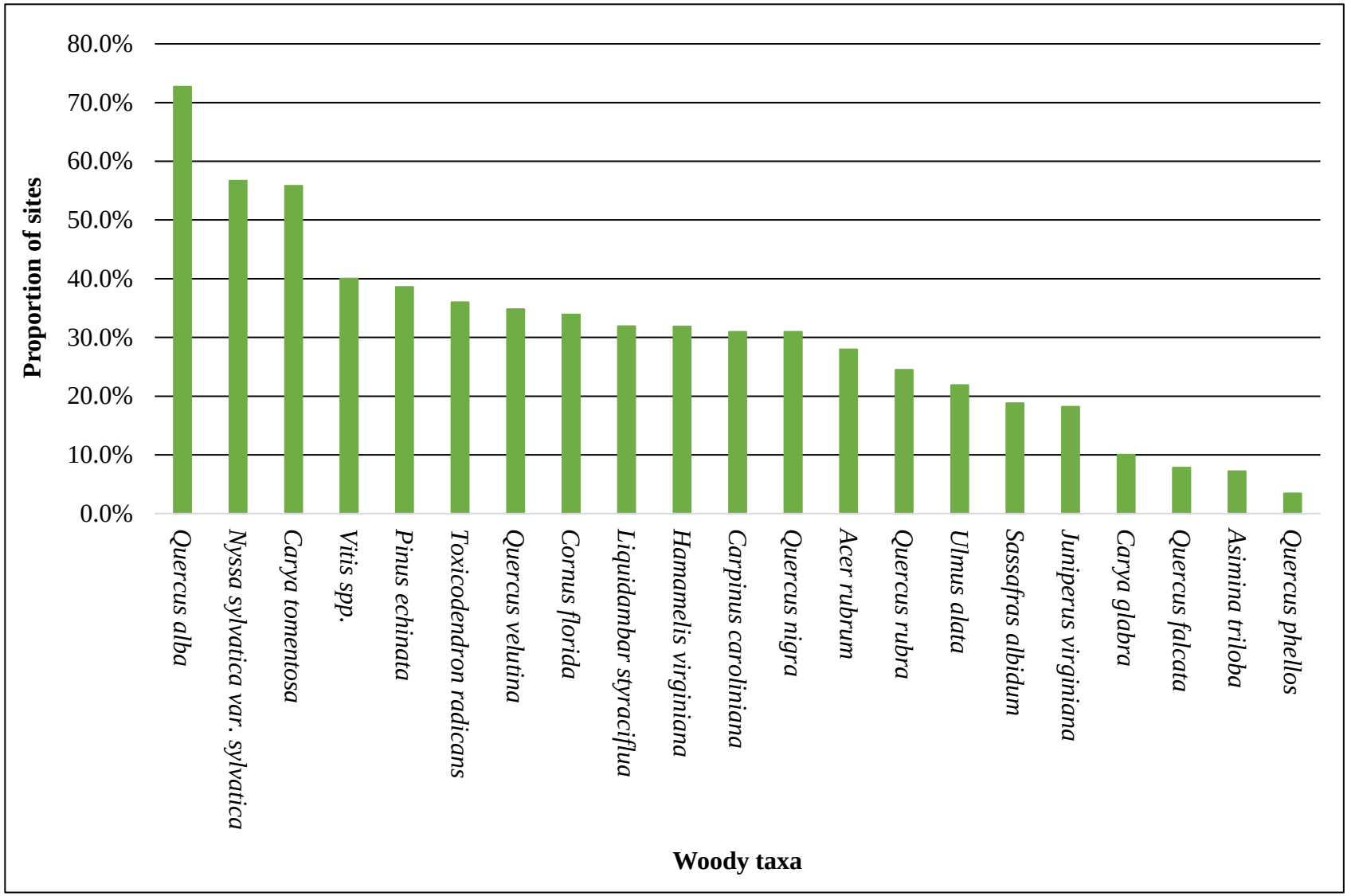


Figure 13. Woody plant taxa that occurred at sites of both varieties of *Castanea pumila*. A total of 21 taxa occurred independently with both varieties across the 64 total sites for this project. Nomenclature follows Gentry et al. (2013).

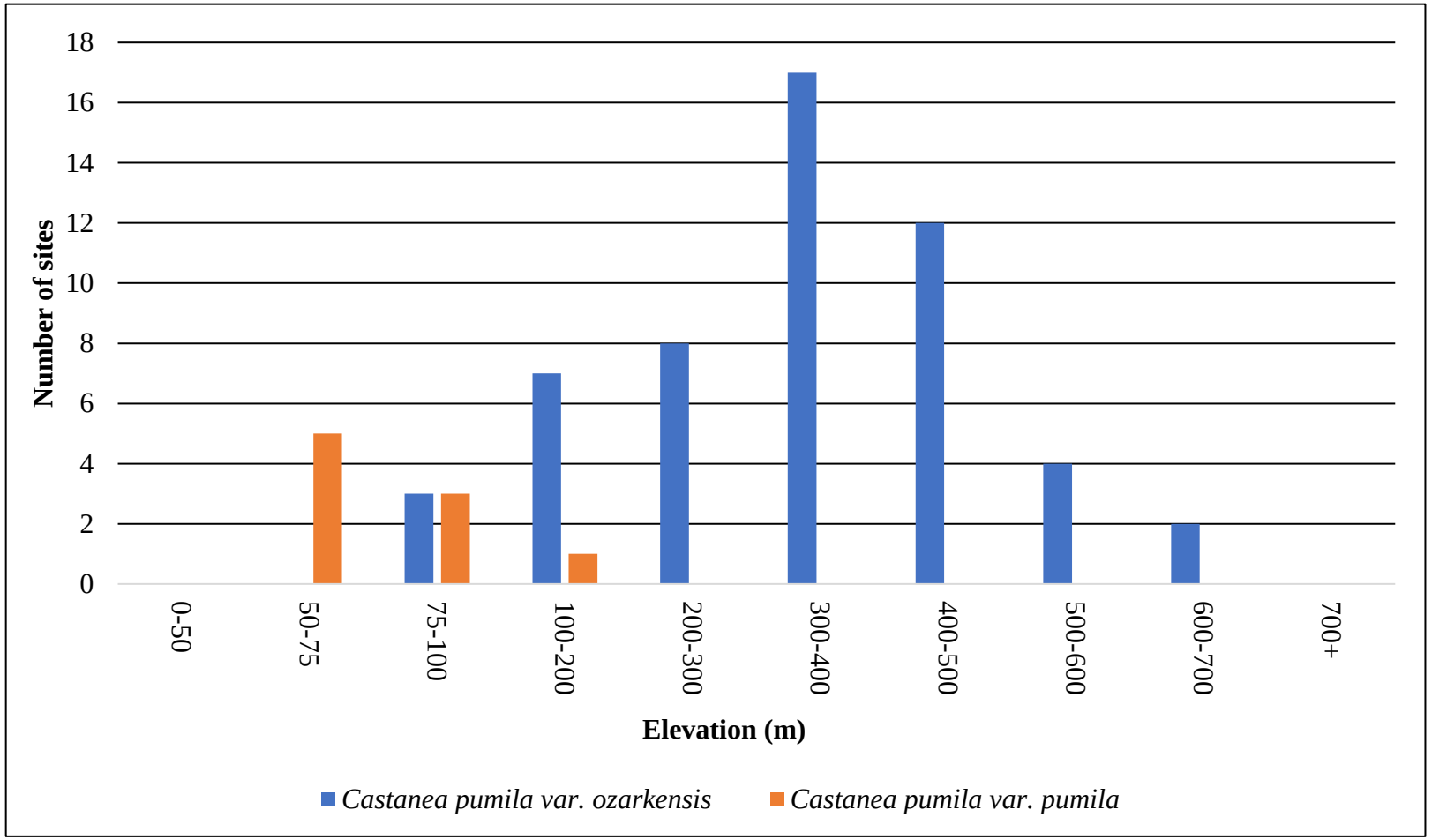


Figure 14. The elevation distribution of sites for each variety. *Castanea pumila* var. *pumila*, n = 9. *Castanea pumila* var. *ozarkensis*, n = 53.

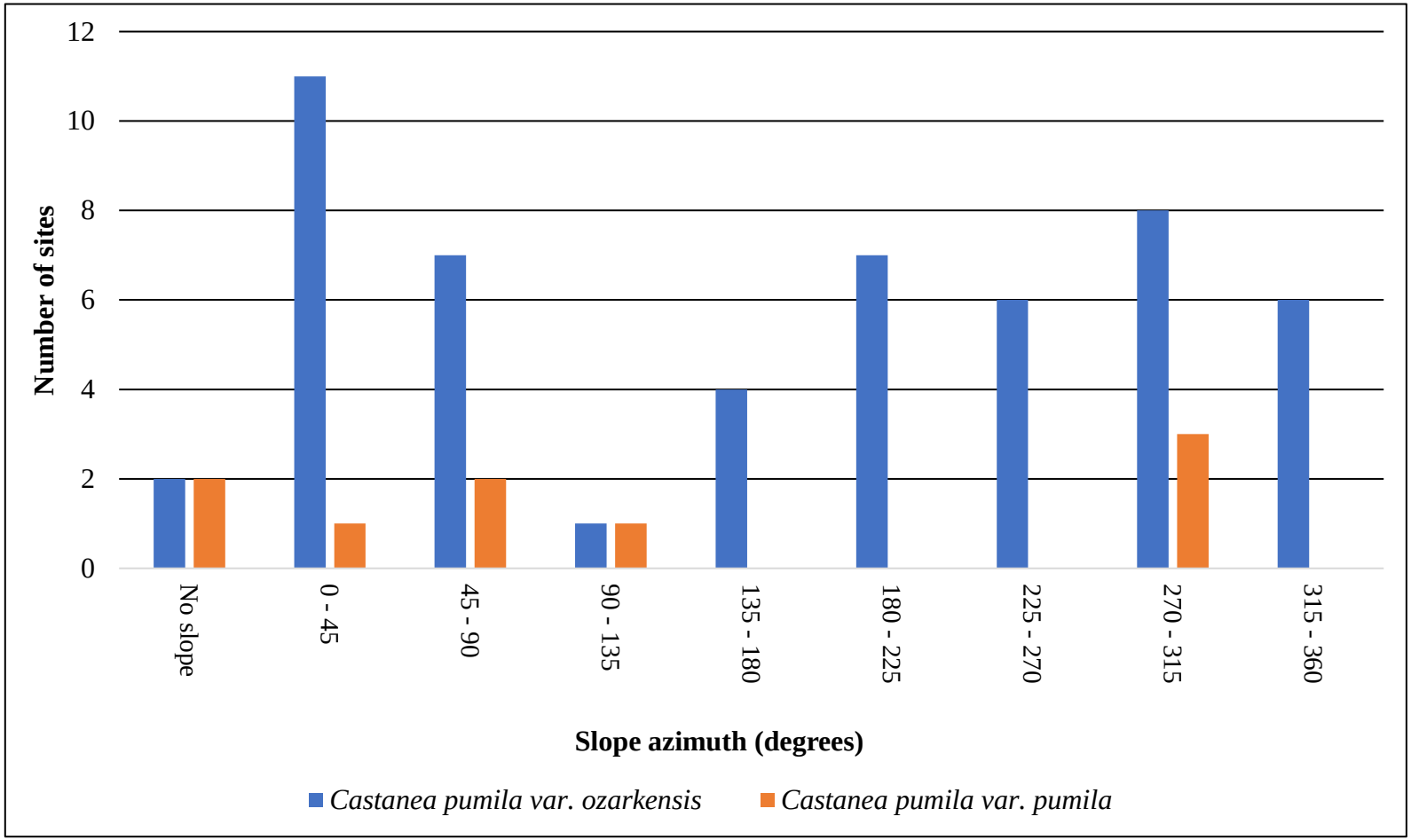


Figure 15. The slope azimuth distribution of sites for each variety. *Castanea pumila* var. *pumila*, n = 9. *Castanea pumila* var. *ozarkensis*, n = 53.

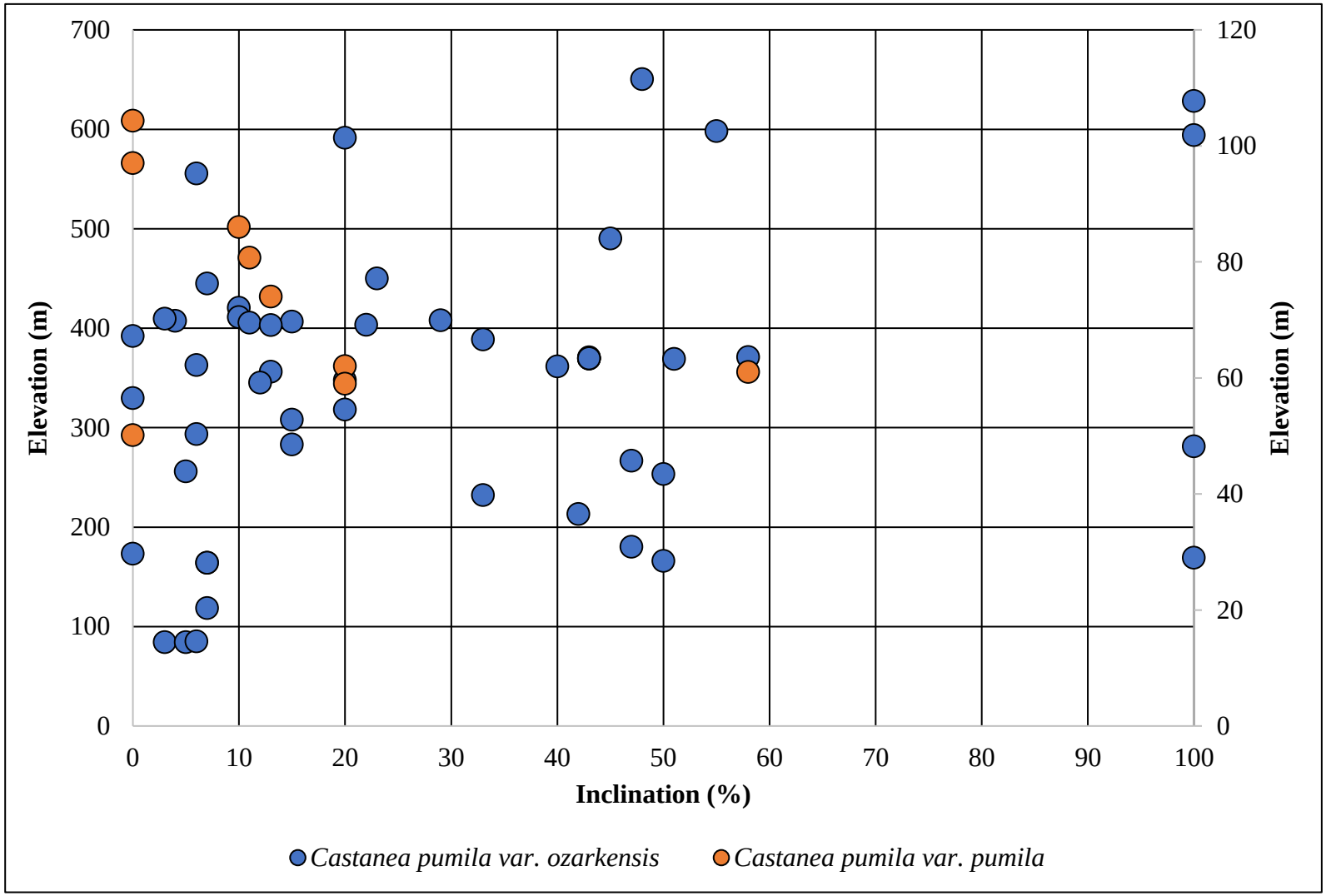


Figure 16. Inclination vs. elevation for sites for both varieties. *Castanea pumila* var. *pumila*, n = 9. *Castanea pumila* var. *ozarkensis*, n = 53. Note that *Castanea pumila* var. *pumila* is represented on a secondary y-axis.

C. Shoot data

The 20 total clones of *C. pumila* var. *pumila* were observed to consist of a total of 72 shoots (both living and dead). Individual clones of this variety ranged from 1 to 8 shoots with the mean being 3.6 shoots per clone. The 53 total clones of *C. pumila* var. *ozarkensis* were observed to consist of a total of 294 shoots (both living and dead), ranging from 1 to 21 shoots per clone, with a mean of 4.45 shoots per clone. The difference in the number of shoots per individual between the varieties was determined to lack statistical significance, as evidenced by a p-value of 0.40379. These data are presented in Table 2.

1. Living status of shoots

Of the 366 total shoots observed in this study, 75.4% (or 276 shoots) were alive and 24.6% (or 90 shoots) were dead at the time of observation. *Castanea pumila* var. *pumila* had the greatest proportion of shoots living with 91.7% (66 shoots) of that variety's total 72 shoots. Comparatively, 71.4% of observed total of 294 shoots of *Castanea pumila* var. *ozarkensis* were living at the time of observation. These data are represented in Table 2 and Figure 17.

2. Height of shoots

Clones of *C. pumila* var. *pumila* were observed to consist of shoots ranging in height from 0.5 to 9 m, with a mean height of 2.2 m. Similarly, clones of *C. pumila* var. *ozarkensis* were observed to consist of shoots ranging from 0.25 to 14 m in height, with a mean height of 2.08 m. The difference observed in mean shoot height for the two varieties was not statistically significant, as evidenced by a p-value of 0.57341. These data are presented in Table 2.

3. DBH of shoots

Shoots of *C. pumila* var. *pumila* were observed to range in DBH from less than 1 cm to greater than 20 cm, with a mean DBH of 2.9 cm. Similarly, shoots of *C. pumila* var. *ozarkensis* ranged from 0.25 cm. to 17 cm. DBH, with a mean diameter of 2.4 cm. The difference observed in mean shoot DBH for the two varieties was not statistically significant, as evidenced by a p-value of 0.175702. These data are presented in Table 2.

Table 2. Shoot data for both varieties of *Castanea pumila*.

	Castanea pumila* var. *ozarkensis	***Castanea pumila* var. *pumila***
No. of sites	53	9
No. of clones	65	20
No. of shoots	294	72
Mean shoots/clone	4.523	3.600
Range (shoots/clone)	1.0 - 21.0	1.0 - 8.0
p - value	0.403787791	
Shoot height (m)		
Mean	2.08	2.19
Range	0.25 - 14	0.5 - 9.0
p - value	0.573409882	
Shoot DBH (cm)		
Mean	2.4	2.88
Range	0.25 - 17.0	1.0 - 20.0
p - value	0.175702195	
Living status of shoots		
No. Living	210	66
No. Dead	84	6
Living (%)	71.40%	91.70%
Dead (%)	28.60%	8.30%

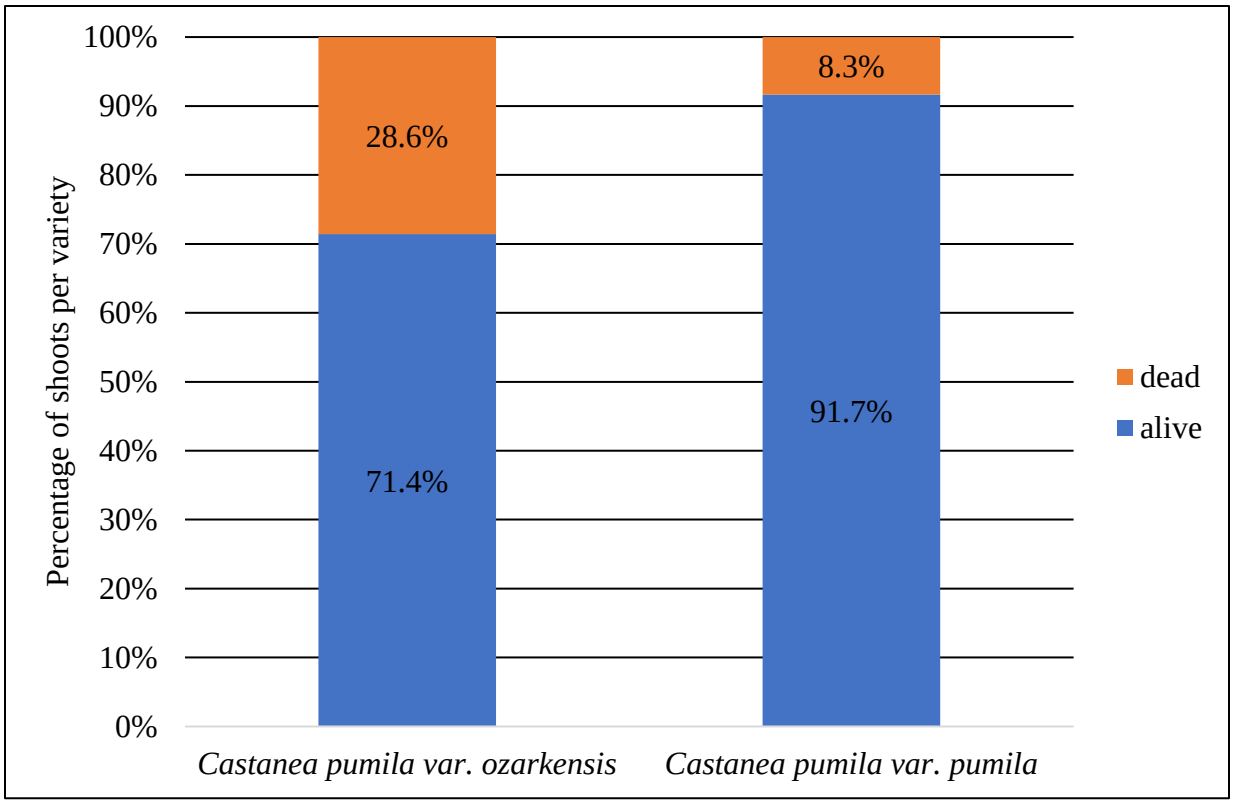


Figure 17. Shoot living status for each variety. *Castanea pumila* var. *pumila*, n = 72 total. *Castanea pumila* var. *ozarkensis*, n = 294 total.

4. Evidence of blight infection

Any indication of infection by the chestnut blight fungus on shoots was noted. Evidence could consist of cankers, cracks, and/or bark that appeared to be unnaturally unhealthy. Of the observed 72 shoots of *C. pumila* var. *pumila*, approximately 34.7% (25 shoots) showed signs of infection with the chestnut blight fungus. A larger proportion, 58.2%, or 171 out of 294 total shoots of *C. pumila* var. *ozarkensis* showed signs of infection.

5. Indication of fruit

Any indication of fruiting by a clone was noted. In this parameter, shoots were either not fruiting, developing fruit, or had developed fruit in a past season as evidenced by burs nearby. A small proportion of each variety indicated fruiting activity. A total of 9.7%, or 7 shoots, of *C. pumila* var. *pumila* had developing fruit present at the time of observation and 0% of shoots for that variety had old burs and/or previous seasons' fruit nearby. Comparatively, 7.8%, or 23 total shoots, of *C. pumila* var. *ozarkensis* had either developing fruit present, or previous seasons' fruit and/or burs nearby.

D. Multivariate morphometric analysis of vegetation

Figure 18 displays a side-by-side comparison of specimens for both varieties. The results of the morphometric analysis on the voucher specimen vegetation is displayed in Table 3.

1. Leaf blade length

The mean leaf blade length for *C. pumila* var. *pumila* specimens from Arkansas was 110.77 mm with a range of 69.67 mm to 174.39 mm. Arkansas specimens of *C. pumila* var. *ozarkensis* exhibited a mean blade length of 164.78 mm, ranging from 102.97 mm to 224.62 mm.

Additionally, specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) had a mean leaf blade length of 97.38 mm, ranging from 50.52 mm to 162.41 mm. The difference in leaf blade length between the three samples was determined to be statistically significant as evidenced by a p-value of 1.01262E-65. These data are presented in Figures 19 and 20.

2. Leaf blade width

The mean leaf blade width for *C. pumila* var. *pumila* specimens from Arkansas was 50.33 mm. with a range of 25.75 mm to 86.64 mm. Arkansas specimens of *C. pumila* var. *ozarkensis* exhibited a mean blade width of 68.87 mm, ranging from 34.99 mm to 106.62 mm. Additionally, specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) had a mean leaf blade width of 39.76 mm, ranging from 27.54 mm to 60.82 mm. The difference in leaf blade width between the three samples was determined to be statistically significant as evidenced by a p-value of 6.41843E-49. These data are presented in Figures 19 and 21.

3. Leaf blade length to width ratio

The mean leaf blade length to width ratio for *C. pumila* var. *pumila* specimens from Arkansas was 2.22 with a range of 1.75 to 3.06. Arkansas specimens of *C. pumila* var. *ozarkensis* exhibited a mean blade length to width ratio of 2.43, ranging from 1.60 to 3.39. Additionally, specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) had a mean leaf blade length to width ratio of 2.44, ranging from 1.33 to 3.59. The difference in leaf blade length to width ratio between the three samples was determined to be

statistically significant as evidenced by a p-value of 9.03341E-07. These data are presented in Figure 22.

4. Leaf blade widest point, percent of length

Where the widest point of the leaf blade occurred along the length of the leaf blade was noted as a percentage of total leaf blade length, measured from the base. The widest point of the leaf blade of *C. pumila* var. *pumila* specimens from Arkansas occurred at a mean of 55.09% of the leaf blade's length, with a range of 43% to 70%. The widest point of leaf blade for Arkansas specimens of *C. pumila* var. *ozarkensis* occurred at a mean of 55.29%, with a range of 38% to 72%. Additionally, specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) were widest with a mean value of 55.25% of the blade's total length, ranging from 43% to 67%. The difference in the location of the leaf blade's widest point in relation to the leaf blade's total length between the three samples was not determined to be statistically significant as evidenced by a p-value of 0.939776875. Figure 23 presents these data.

5. Leaf blade margin teeth count

The mean number of margin teeth per side for *C. pumila* var. *pumila* specimens from Arkansas was 13.37, with a range of 9 to 17 teeth per side. Arkansas specimens of *C. pumila* var. *ozarkensis* exhibited a mean number of margin teeth per side of 15.4, ranging from 10 to 22 teeth per side. Additionally, specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) had a mean number of margin teeth per side of 13.59, ranging from 9 to 21 teeth per side. The difference in leaf blade width between the three samples was determined to be statistically significant as evidenced by a p-value of 1.0967E-13. These data are presented in Figure 24.

Table 3. Multivariate morphometric analysis of vegetation results.

	AR *ozarkensis* n = 172	**AR *pumila* n = 118**	**VT *pumila* n = 44**
Mean **blade length (mm)**	164.78	110.77	97.38
Range	102.97 - 224.62	69.67 - 174.39	50.52 - 162.41
p-value	1.01262E-65		
Mean **blade width (mm)**	68.87	50.33	39.76
Range	34.99 - 106.62	25.75 - 86.64	27.54 - 60.82
p-value	6.41843E-49		
Mean **blade length to width ratio**	2.43	2.22	2.44
Range	1.60 - 3.39	1.75 - 3.06	1.33 - 3.59
p-value	9.03341E-07		
Mean **widest point % of length**	55.29%	55.09%	55.25%
Range	0.38 - 0.72	0.43 - 0.70	0.43 - 0.67
p-value	0.939776875		
Mean **teeth/ margin**	15.4	13.37	13.59
Range	10.0 - 22.0	9.0 - 17.0	9.0 - 21.0
p-value	1.0967E-13		
Mean **teeth/ cm blade length**	0.95	1.24	1.48
Range	0.67 - 1.69	0.83 - 2.07	0.71 - 2.44
p-value	2.01101E-44		
Mean **petiole length (mm)**	7.34	4.48	8.11
Range	4.32 - 12.3	2.27 - 7.15	4.24 - 18.48
p-value	8.27562E-46		
Mean **petiole diameter (mm)**	1.22	0.93	0.93
Range	0.73 - 2.02	0.61 - 1.38	0.41 - 1.62
p-value	4.43667E-27		
Mean **petiole ratio**	6.12	4.92	9.33
Range	1 - 10.42	2.39 - 9.81	4.46 - 18.12
p-value	9.02295E-33		

Figure 18. Voucher specimens of *C. pumila* for comparison. Left: A *C. pumila* var. *ozarkensis* specimen from Scott County, AR. Right: A *C. pumila* var. *pumila* specimen from Miller County, AR.

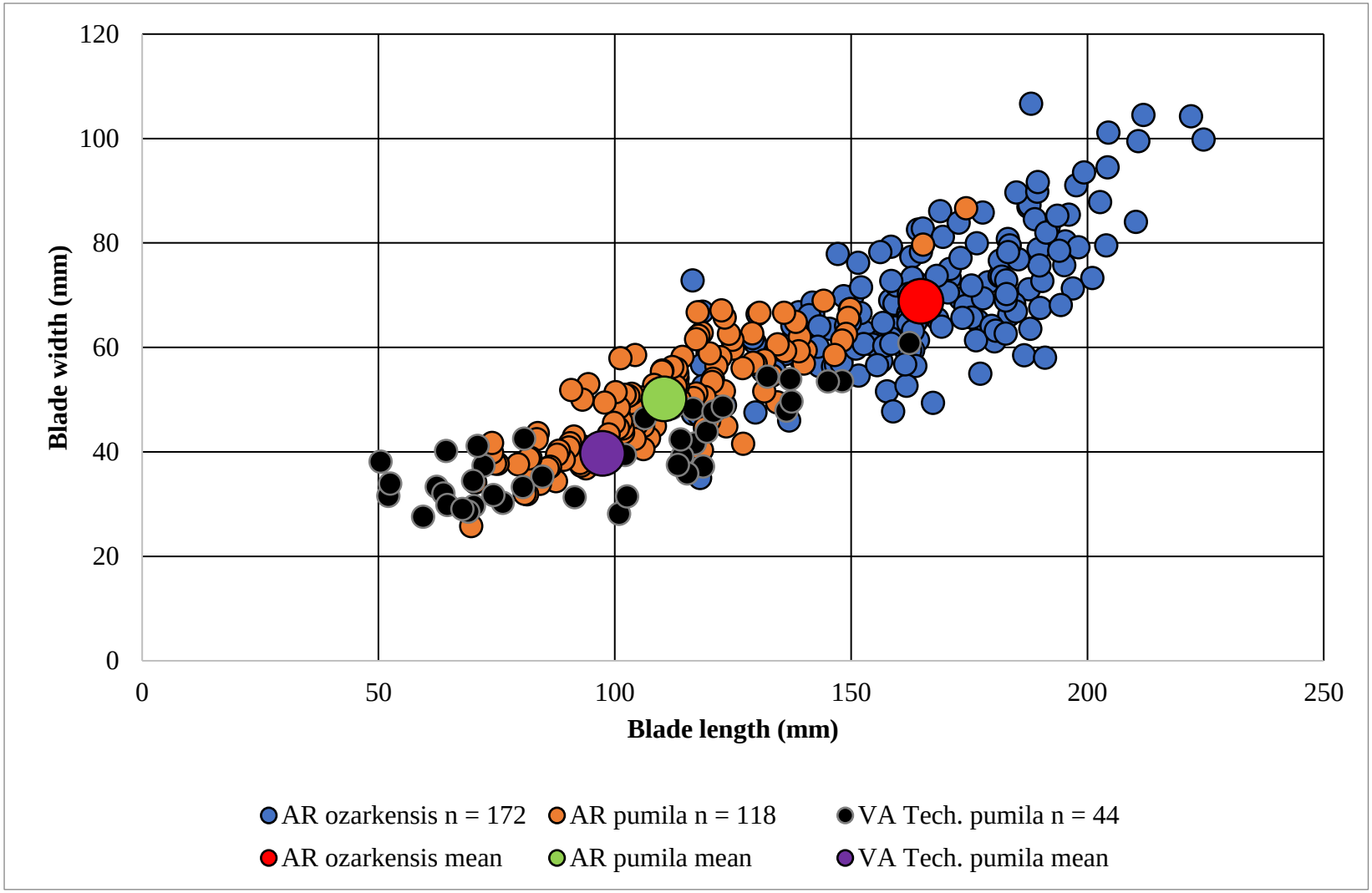


Figure 19. Leaf blade length vs. width for all 334 leaves analyzed. Small circles: blue = *C. pumila* var. *ozarkensis* from AR, orange = *C. pumila* var. *pumila* from AR, black = *C. pumila* var. *pumila* from VA Tech. loan. Large circles: red = mean of *C. pumila* var. *ozarkensis* from AR, green = mean of *C. pumila* var. *pumila* from AR, purple = mean of *C. pumila* var. *pumila* from VA Tech. loan.

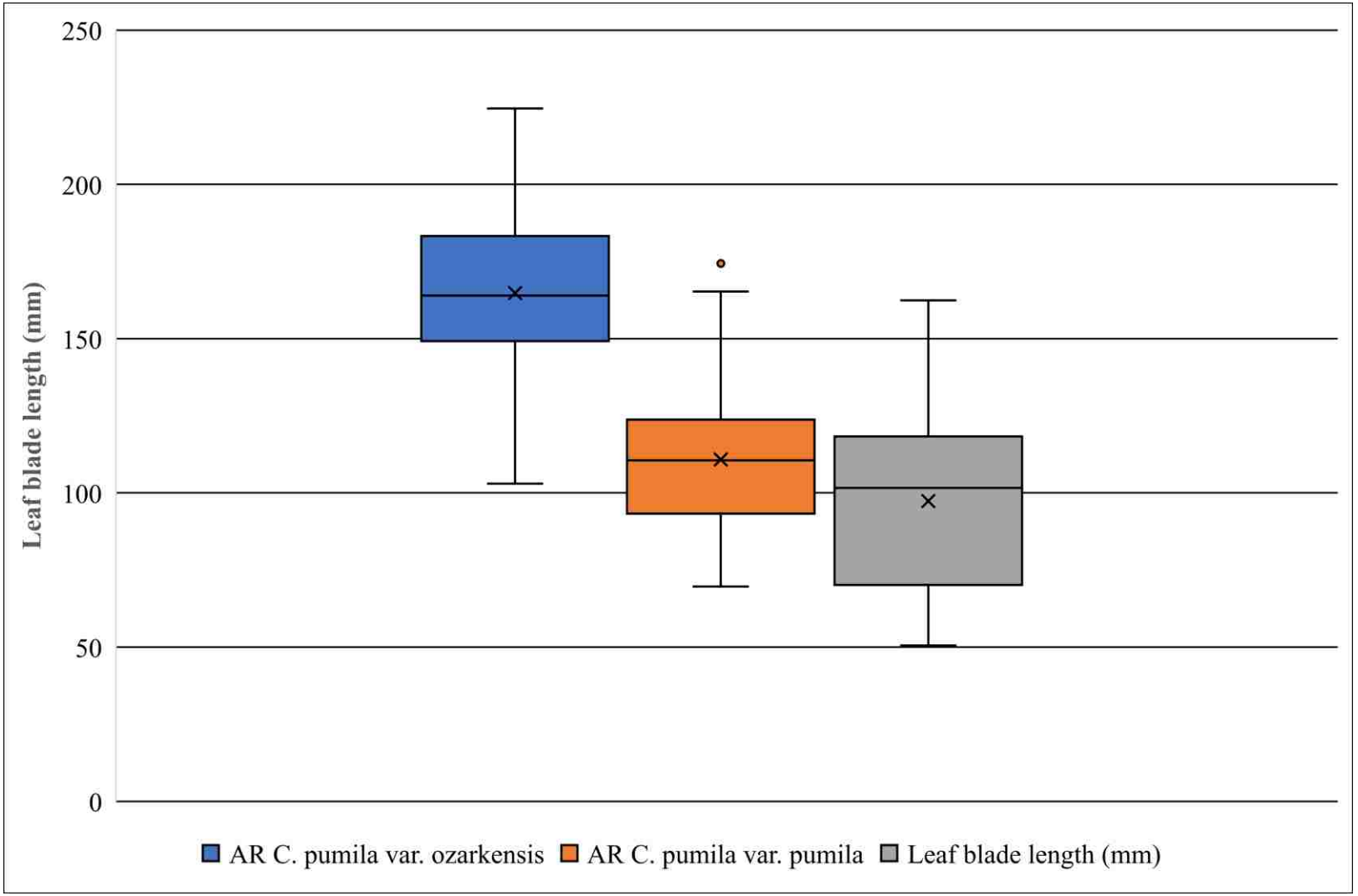


Figure 20. Leaf blade length for the three sets of samples. This graph represents the middle 50%, range, median, and mean of blade lengths for each sample. p – value = 1.0E-65.

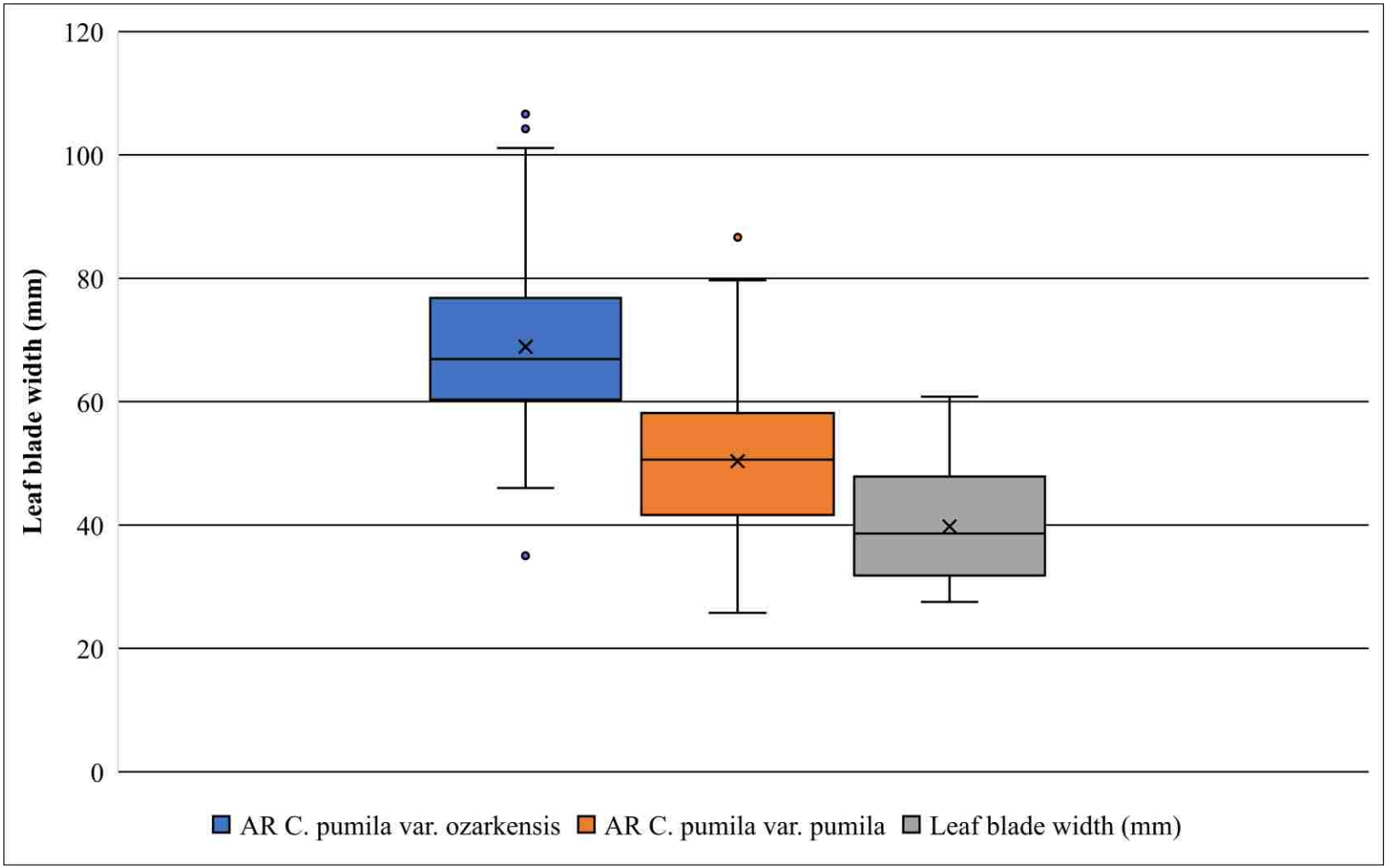


Figure 21. Leaf blade width for the three sets of samples. This graph represents the middle 50%, range, median, and mean of blade lengths for each sample. p – value = 6.42E-49.

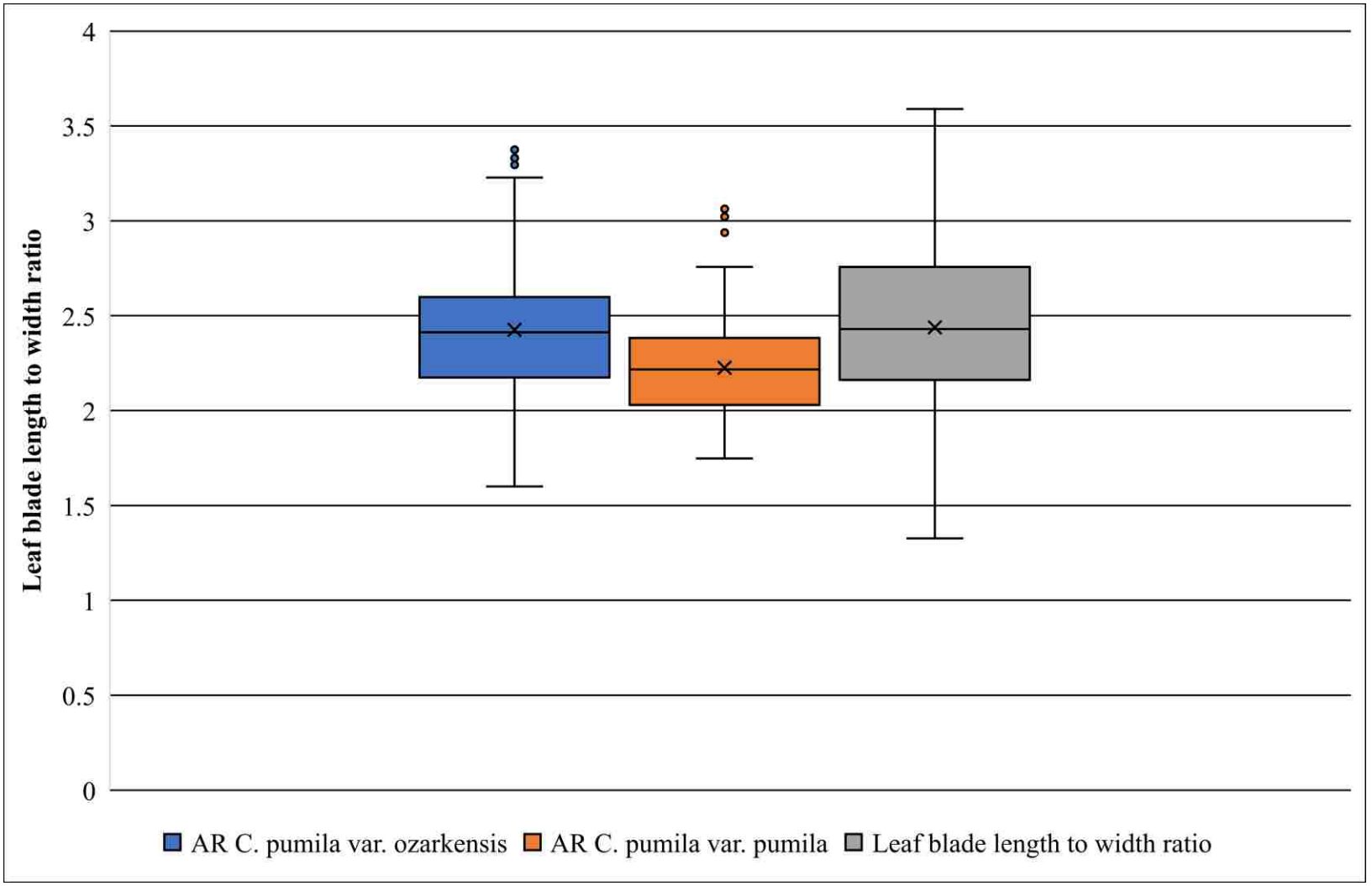


Figure 22. Leaf blade length to width ratio for the three sets of samples. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 9.03E-07.

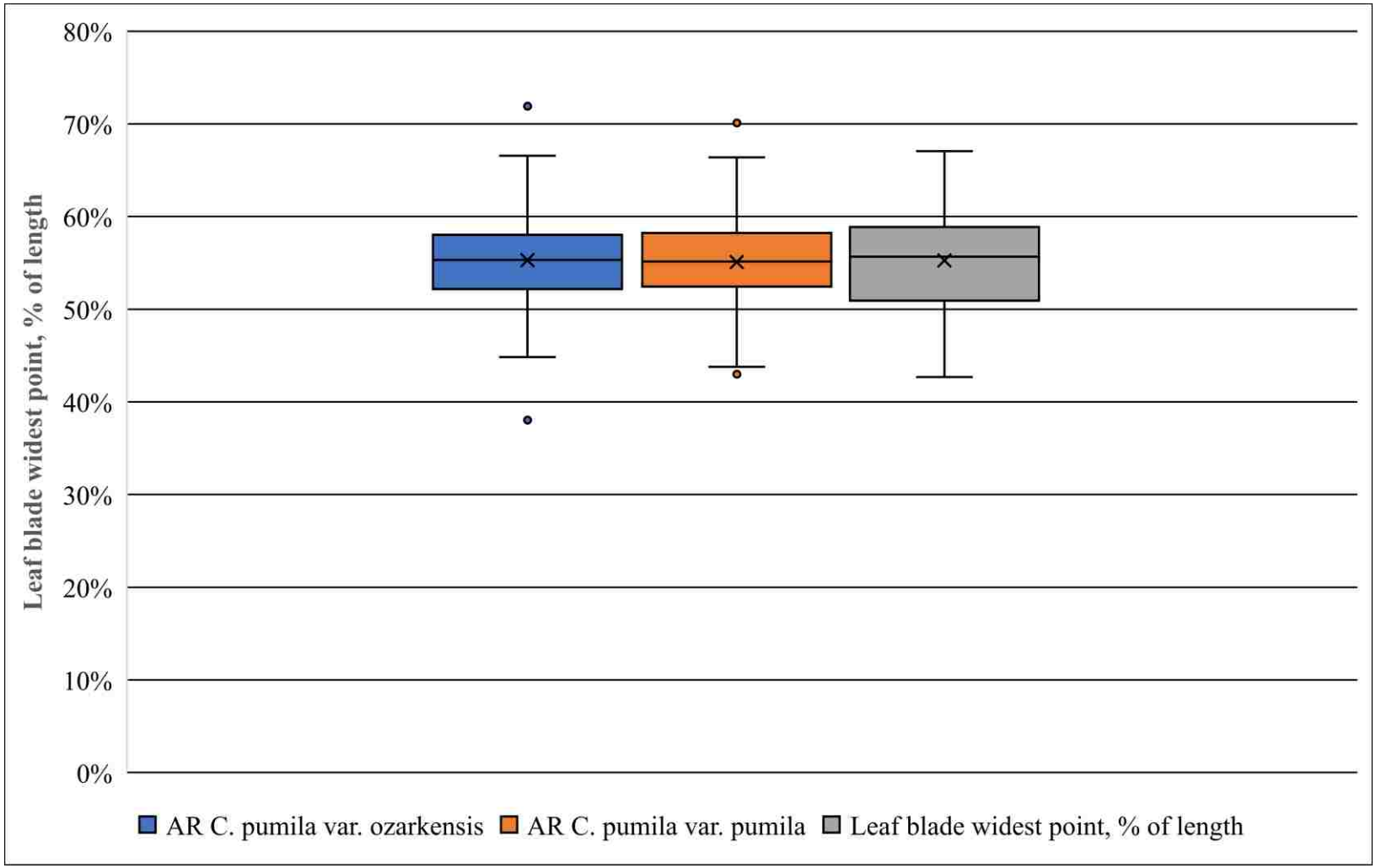


Figure 23. Leaf blade widest point location in relation to blade length for the three sets of samples. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 0.939777.

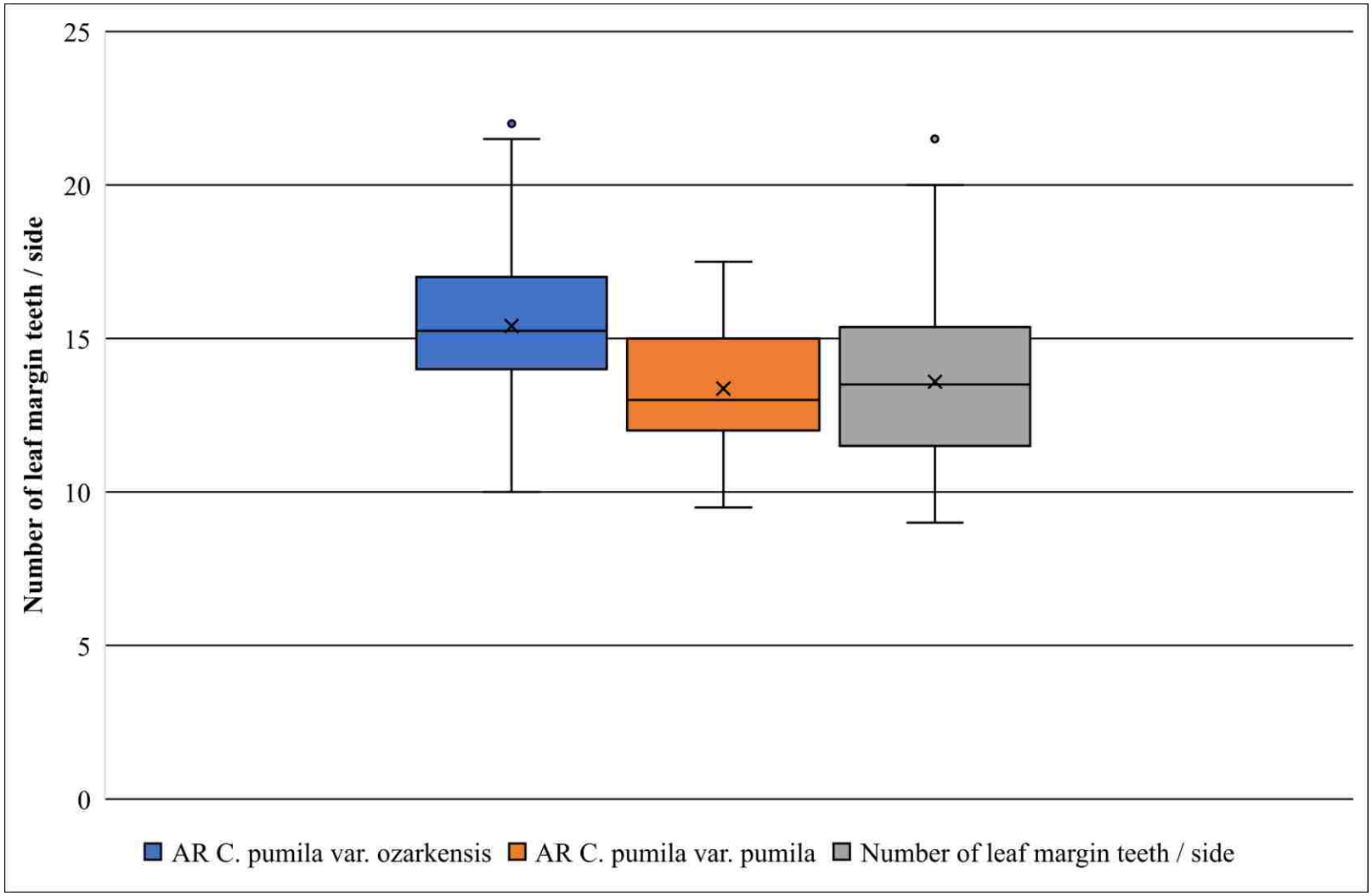


Figure 24. Number of leaf margin teeth per side for the three sets of samples. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 1.1E-13.

6. Leaf blade margin teeth spacing

The spacing of margin teeth was determined and is represented as number of teeth per cm of blade length. The mean margin teeth spacing for *C. pumila* var. *pumila* specimens from Arkansas was 1.24 teeth/cm, with a range of 0.83 to 2.07 teeth/cm. Arkansas specimens of *C. pumila* var. *ozarkensis* exhibited a mean margin teeth spacing of 0.95 teeth/cm, ranging from 0.67 to 1.69 teeth/cm. Additionally, specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) had a mean margin teeth spacing of 1.48 teeth/cm, ranging from 0.71 to 2.44 teeth/cm. The difference in leaf blade width between the three samples was determined to be statistically significant as evidenced by a p-value of 2.01101E-44. These data are presented in Figure 25.

7. Petiole length

The mean petiole length for *C. pumila* var. *pumila* specimens from Arkansas was 4.48 mm. with a range of 2.27 mm to 7.15 mm. Arkansas specimens of *C. pumila* var. *ozarkensis* exhibited a mean petiole length of 7.34 mm, ranging from 4.32 mm to 12.3 mm. Additionally, specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) had a mean petiole length of 8.11 mm, ranging from 4.24 mm to 18.48 mm. The difference in petiole length between the three samples was determined to be statistically significant as evidenced by a p-value of 1.01262E-65. These data are presented in Figure 26.

8. Petiole diameter

The mean petiole diameter for *C. pumila* var. *pumila* specimens from Arkansas was 0.93 mm with a range of 0.61 mm to 1.38 mm. Arkansas specimens of *C. pumila* var. *ozarkensis* exhibited a mean petiole diameter of 1.22 mm, ranging from 0.73 mm to 2.02 mm. Additionally,

specimens of *C. pumila* var. *pumila* collected outside of Arkansas (Virginia Tech Herbarium loan) had a mean petiole diameter of 0.93 mm, ranging from 0.41 mm to 1.62 mm. The difference in petiole diameter between the three samples was determined to be statistically significant as evidenced by a p-value of 4.43667E-27. These data are presented in Figure 27.

E. Single tree vegetation analysis

The results of the morphometric analysis performed on a total of six specimens from a single *C. pumila* var. *ozarkensis* tree for purposes of comparing vegetation at different forest strata, are presented in Table 4.

1. Leaf blade length

The leaf blade length of the specimens analyzed varied greatly. The blade length of specimens collected from a height of 3 m ranged from 213.28 mm to 365.71 mm, with a mean of 269.68 mm, whereas specimens collected at a height of 5 m ranged from 161.67 mm to 244.10 mm, with a mean of 209.85 mm, and that of the specimens collected at a height of 8 m ranged from 111.03 mm to 174.27 mm, with a mean of 150.06 mm. The differences in blade length observed between the three samples were determined to be statistically significant, as evidenced by a p – value of 3.01563E-08. These data are presented in Figure 28.

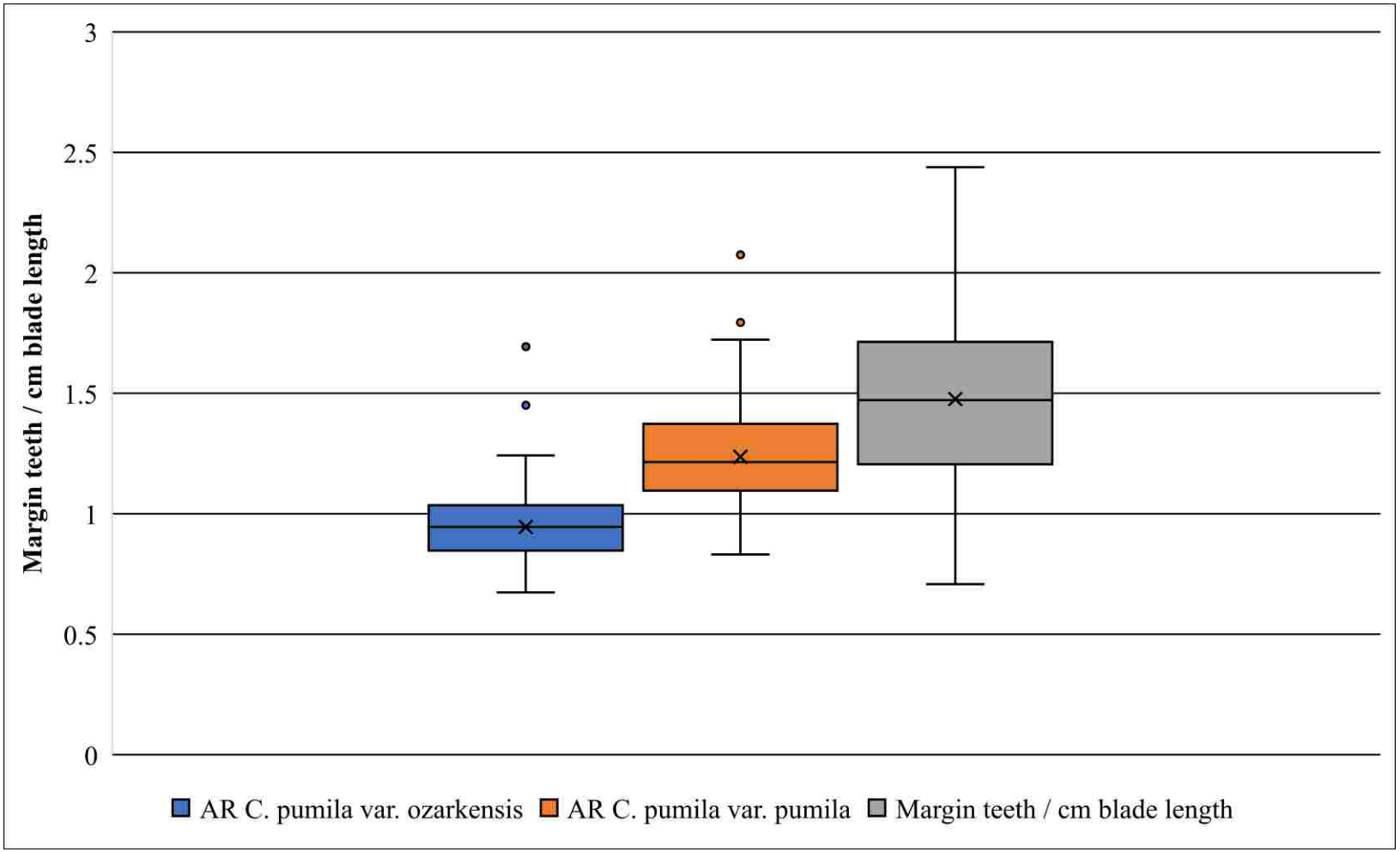


Figure 25. Number of leaf margin teeth per cm blade length for the three sets of samples. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 2.01E-44.

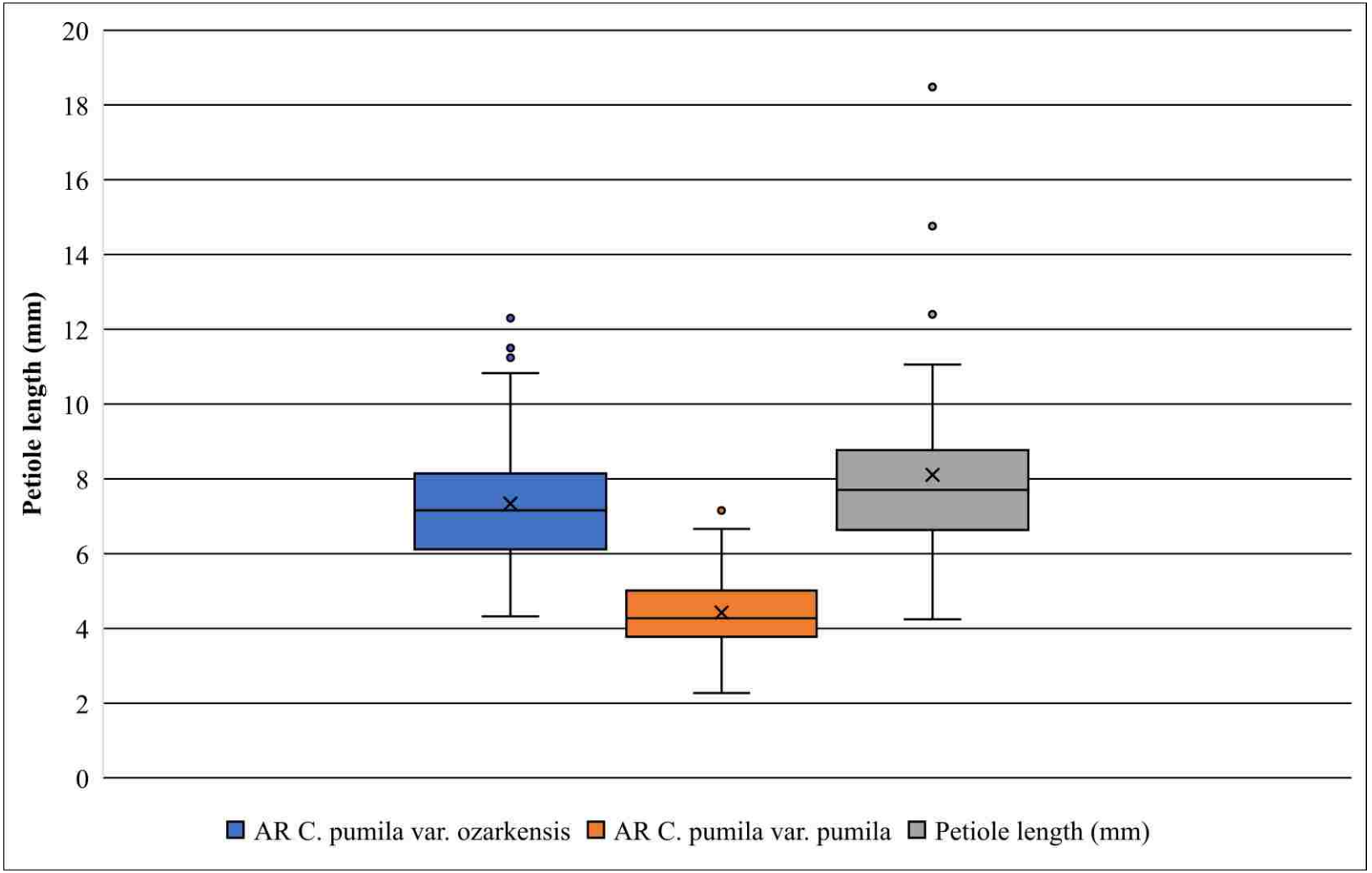


Figure 26. Leaf petiole length for the three sets of samples. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 8.28E-46.

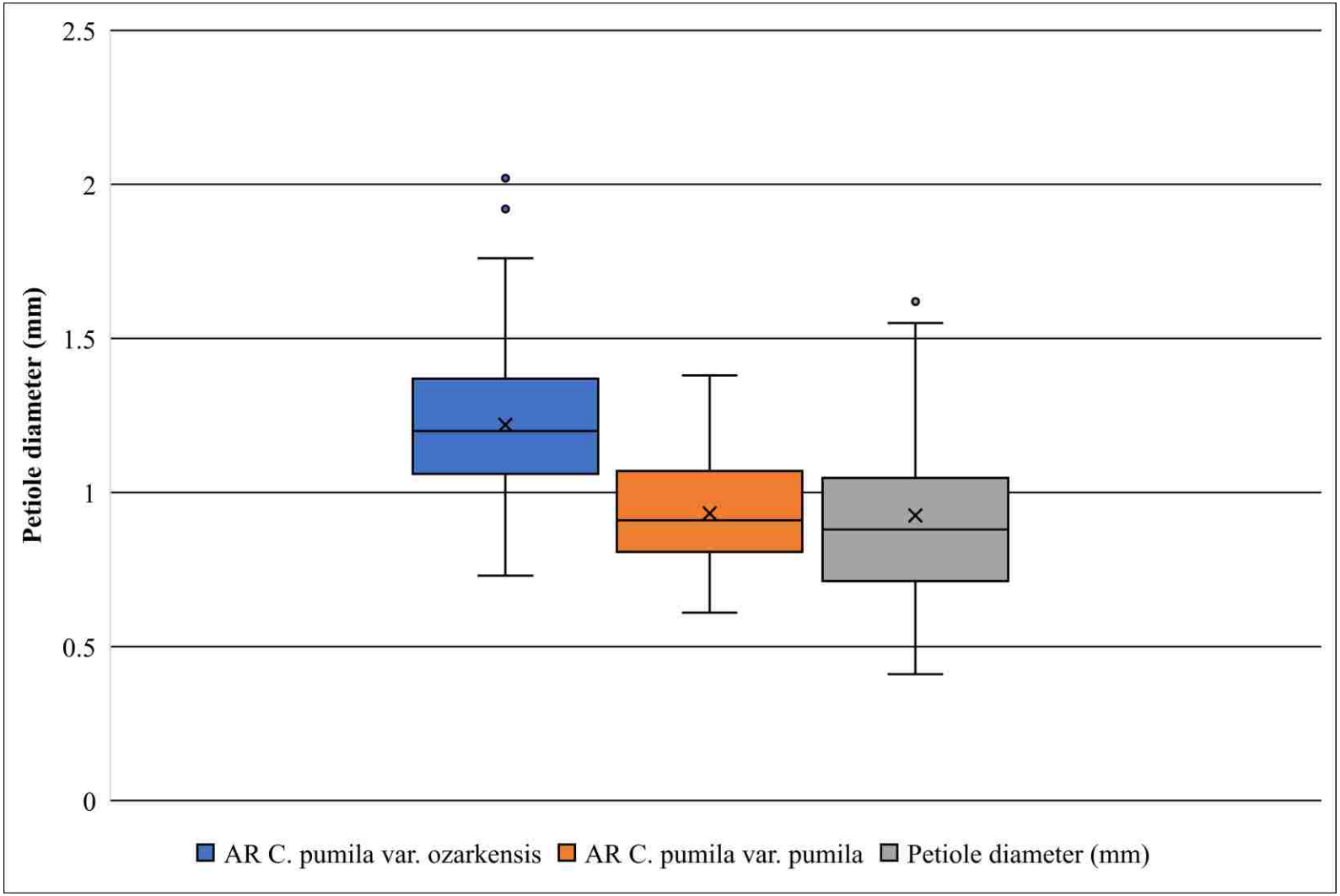


Figure 27. Leaf petiole diameter for the three sets of samples. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 4.44E-27.

Table 4. Single tree morphometric vegetation analysis results

	3 m - full shade	5 m - partial shade	8 m - full sun
Leaf blade length (mm)			
Mean	269.68	209.85	150.06
Range	213.28 - 365.71	161.67 - 244.10	111.03 - 174.27
p - value	3.01563E-08		
Leaf blade width (mm)			
Mean	97.69	89.86	63.00
Range	60.31 - 127.04	73.6 - 116.55	48.23 - 72.71
p - value	1.1151E-05		
Leaf blade length to width ratio			
Mean	2.85	2.35	2.38
Range	2.15 - 3.91	2.07 - 2.73	2.08 - 2.81
p - value	0.011537682		
Leaf blade widest point, percent of length			
Mean	50.34 %	50.52 %	51.64 %
Range	0.45 - 0.60	0.45 - 0.58	0.42 - 0.57
p - value	0.776681534		
Petiole length (mm)			
Mean	10.29	9.32	8.63
Range	8.29 - 11.63	6.91 - 12.50	6.65 - 10.55
p - value	0.054636463		
Petiole diameter (mm)			
Mean	1.29	1.36	1.10
Range	1.13 - 1.45	1.09 - 1.81	0.82 - 1.29
p - value	0.009855002		
Petiole length to diameter ratio			
Mean	8.10	7.02	7.92
Range	6.01 - 10.11	4.55 - 10.59	5.45 - 10.02
p - value	0.229671567		

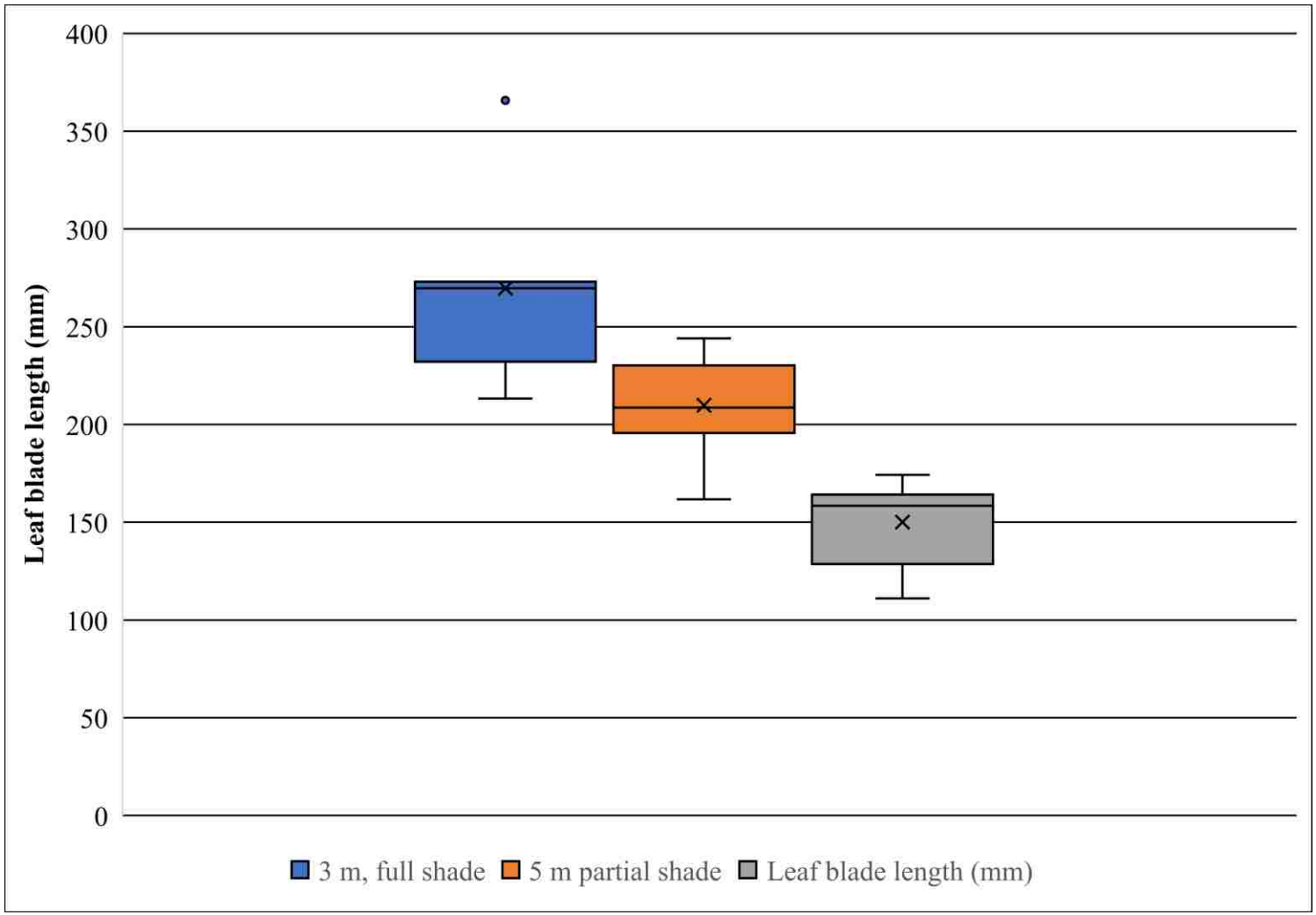


Figure 28. Leaf blade length data for the three sets of samples of the single tree vegetation analysis. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 3.02E-08.

2. Leaf blade width

The leaf blade width of specimens collected from a height of 3 m ranged from 60.31 mm to 127.04 mm, with a mean of 97.69 mm, whereas specimens collected at a height of 5 m ranged from 73.6 mm to 116.55 mm, with a mean of 89.86 mm, and that of the specimens collected at a height of 8 m ranged from 48.23 mm to 72.71 mm, with a mean of 63.00 mm. The differences in blade width observed between the 3 samples was determined to be statistically significant, as evidenced by a p – value of 1.1151E-05. These data are presented in Figure 29.

3. Leaf blade length to width ratio

The leaf blade length to width ratio of specimens collected from a height of 3 m ranged from 2.15 to 3.91, with a mean of 2.85, whereas specimens collected at a height of 5 m ranged from 2.07 to 2.73, with a mean of 2.35, and that of the specimens collected at a height of 8 m ranged from 2.08 to 2.81, with a mean of 2.38. The differences in blade length to width ratio observed between the 3 samples was determined to be statistically significant, as evidenced by a p – value of 0.011537682. These data are presented in Figure 30.

4. Leaf blade widest point, percent of length

Where the widest point of the leaf blade occurred along the length of the leaf blade was noted as a percentage of total leaf blade length, measured from the base. Of specimens collected from a height of 3 m, where the leaf blade's widest point occurred relative to the length ranged from 45% to 60%, with a mean of 50.34%, whereas specimens collected at a height of 5 m ranged from 45% to 58%, with a mean of 50.52%, and that of the specimens collected at a height of 8 m ranged from 42% to 57%, with a mean of 51.64%. The differences in the widest point,

percent of length between the 3 samples was determined to be lack statistically significance, as evidenced by a p – value of 0.776681534. These data are presented in Figure 31.

5. Leaf petiole length

The leaf petiole length of specimens collected from a height of 3 m ranged from 8.29 mm to 11.63 mm, with a mean of 10.29 mm, whereas specimens collected at a height of 5 m ranged from 6.91 mm to 12.50 mm, with a mean of 9.32 mm, and that of the specimens collected at a height of 8 m ranged from 6.65 mm to 10.55 mm, with a mean of 8.63 mm. The differences in petiole length observed between the 3 samples was determined to be approaching statistical significance, as evidenced by a p – value of 0.057636463. These data are presented in Figure 32.

6. Leaf petiole diameter

The leaf petiole diameter of specimens collected from a height of 3 m ranged from 1.13 mm to 1.45 mm, with a mean of 1.29 mm, whereas specimens collected at a height of 5 m ranged from 1.09 mm to 1.81 mm, with a mean of 1.36 mm, and that of the specimens collected at a height of 8 m ranged from 0.82 mm to 1.29 mm, with a mean of 1.10 mm. The differences in petiole diameter observed between the 3 samples was determined to be statistically significant, as evidenced by a p – value of 0.009855002. These data are presented in Figure 33.

7. Leaf petiole length to diameter ratio

The leaf petiole length to diameter ratio of specimens collected from a height of 3 m ranged from 1.13 mm to 1.45 mm, with a mean of 1.29 mm, whereas specimens collected at a height of 5 m ranged from 1.09 mm to 1.81 mm, with a mean of 1.36 mm, and that of the specimens collected at a height of 8 m ranged from 0.82 mm to 1.29 mm, with a mean of 1.10 mm. The differences in petiole length to diameter ratio observed between the 3 samples was

determined to lack statistical significance, as evidenced by a p – value of 0.229671567. These data are presented in Figure 34.

F. Microscopic anatomy

1. Trichomes on leaf surfaces

Across all the specimens of *C. pumila* from Arkansas, a total of three types of trichomes were observed – simple, stellate, and bulbous. Simple and stellate trichomes were observed on some but not all specimens of both varieties, but bulbous trichomes were observed only on the adaxial leaf surface of *C. pumila* var. *ozarkensis* specimens. Additionally, trichome densities across the entire sample varied largely from glabrous to puberulent, to tomentose with little correlation to variety, leaf age, time of collection, or geographic location. Leaf surface features were observed to vary greatly within a single tree, and/or between leaves of a single voucher specimen. Note that the abaxial and adaxial midrib is herein treated separately from either the abaxial or adaxial surface.

2. Abaxial leaf surface

Across all samples of *C. pumila* var. *pumila* and *C. pumila* var. *ozarkensis* two types of trichomes on the abaxial leaf surface were observed – simple and stellate. Of the specimens of *C. pumila* var. pumila, 53.3% of leaves analyzed exhibited a puberulent to tomentose cover of stellate trichomes, and 93.8% of leaves analyzed had simple, solitary trichomes in varying densities. Similarly, 43.8% of the *C. pumila* var. *ozarkensis* leaves analyzed exhibited puberulent to tomentose cover of stellate trichomes, and 59.3% of leaves analyzed had simple, solitary trichomes in varying densities. A total of 6.3% of *C. pumila* var. *pumila* specimens and 40.6% of *C. pumila* var. *ozarkensis* specimens were glabrous on the abaxial surface.

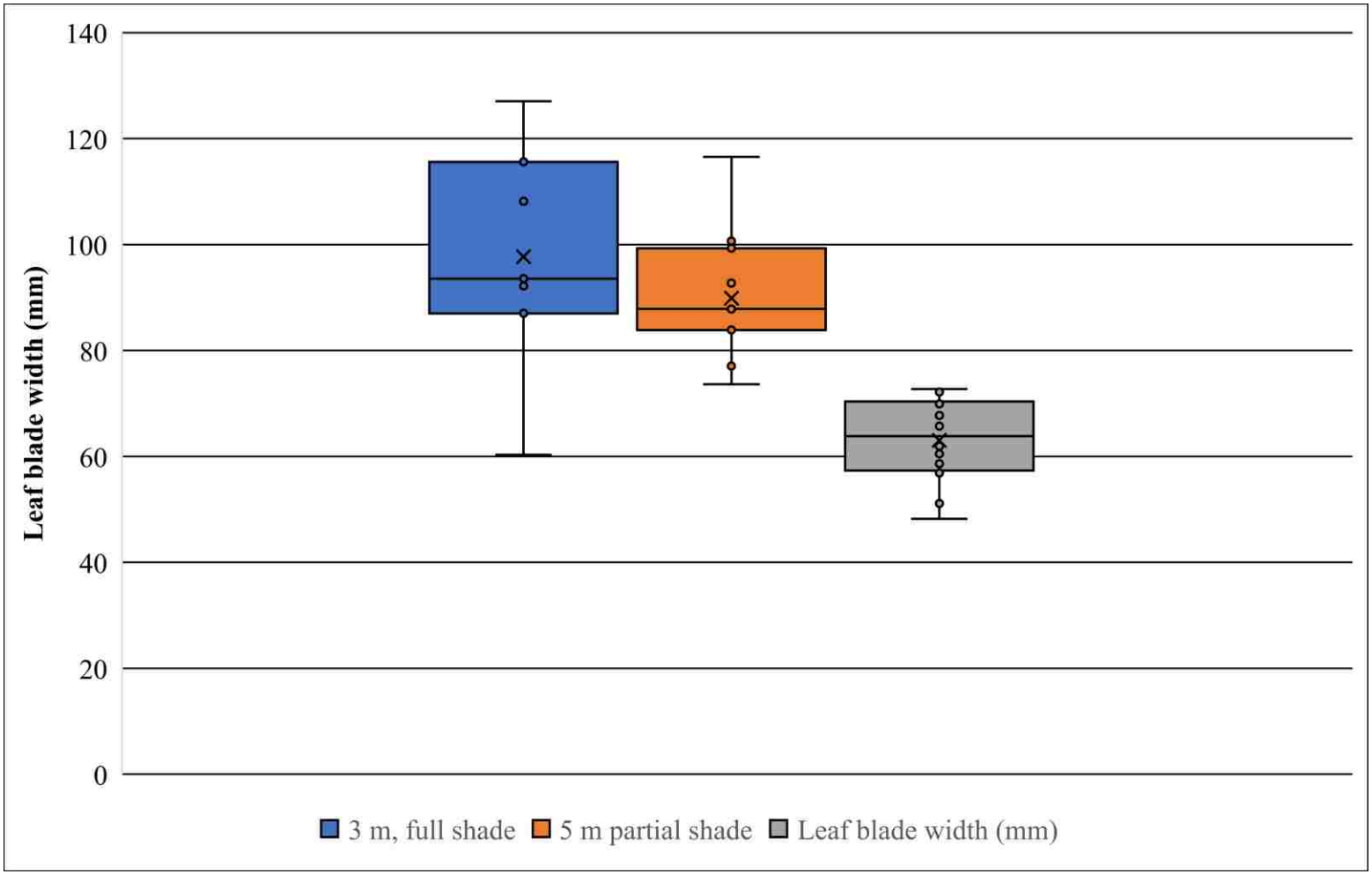


Figure 29. Leaf blade width data for the three sets of samples of the single tree vegetation analysis. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 1.12E-05.

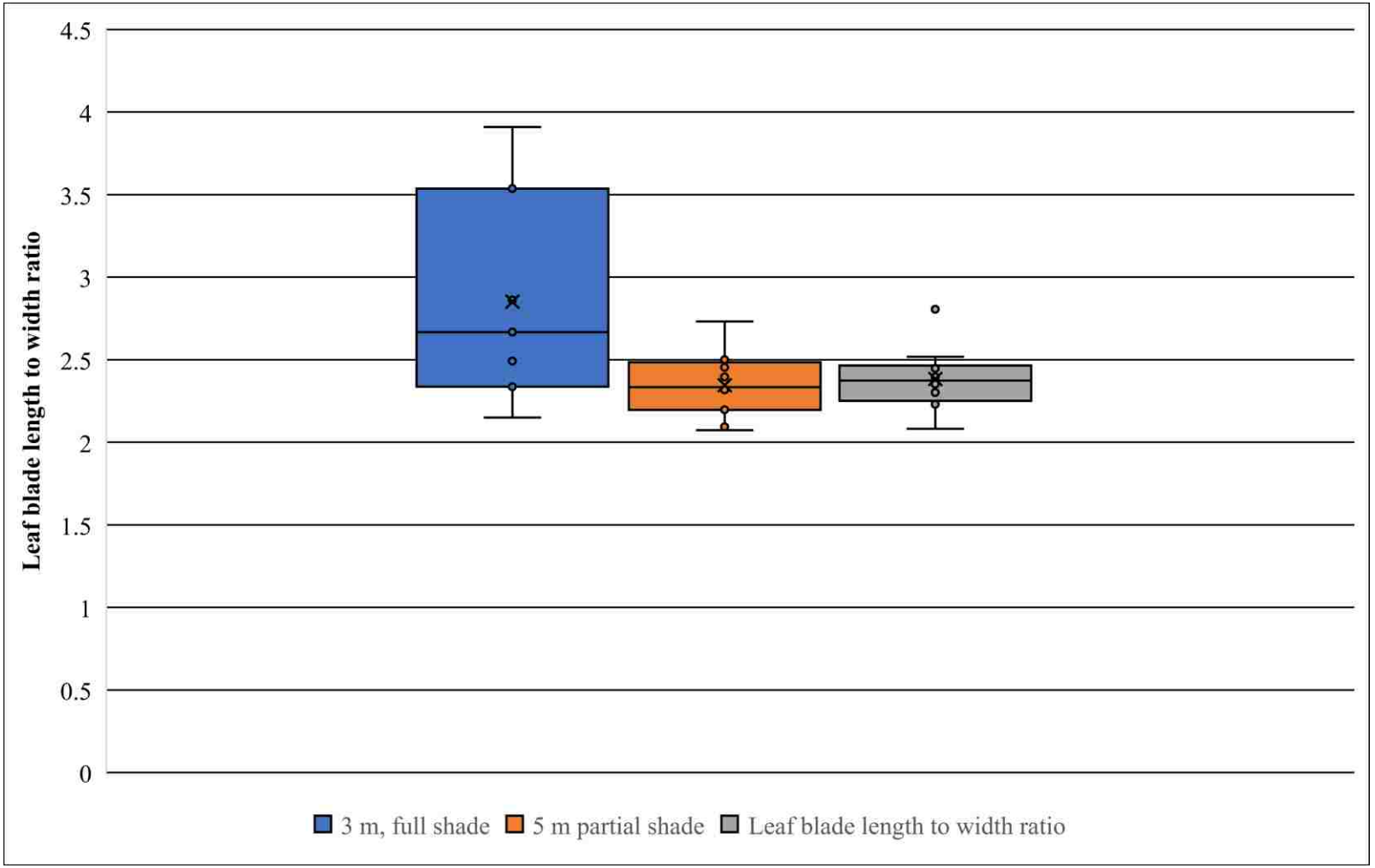


Figure 30. Leaf blade length to width ratio data for the three sets of samples of the single tree vegetation analysis. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 0.011538.

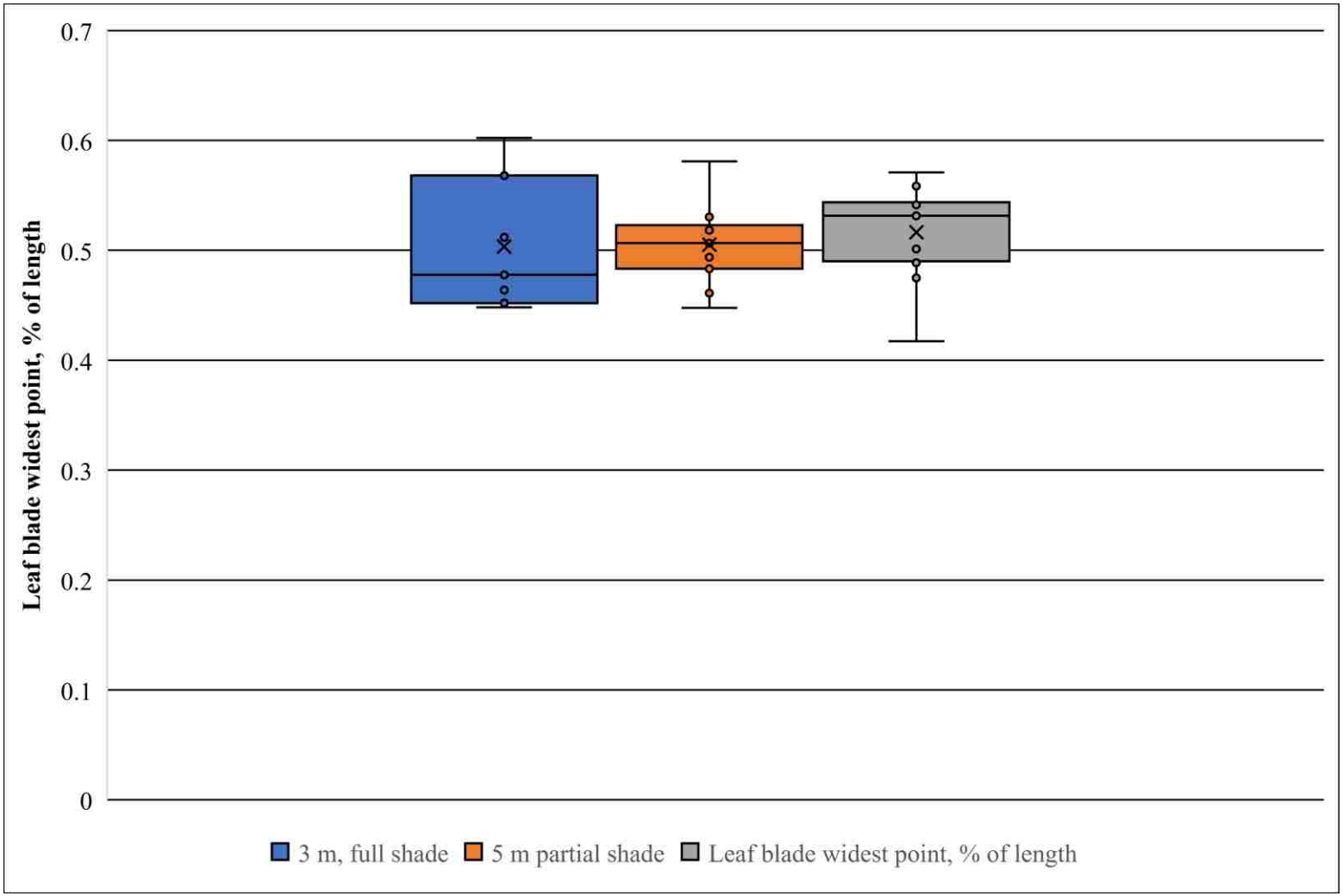


Figure 31. Leaf blade widest point, percent of length data for the three sets of samples of the single tree vegetation analysis. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 0.776682.

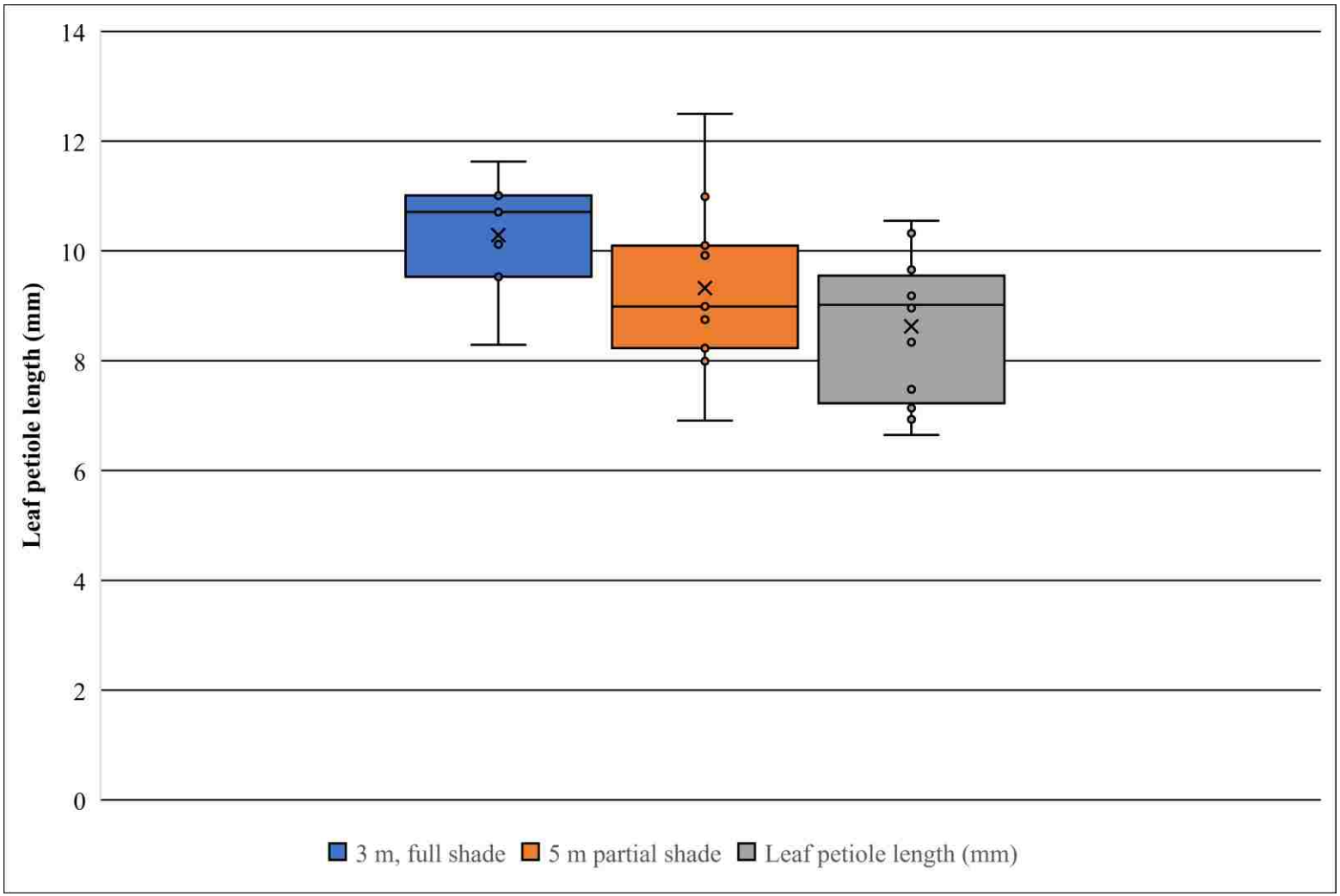


Figure 32. Leaf petiole length data for the three sets of samples of the single tree vegetation analysis. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 0.054636.

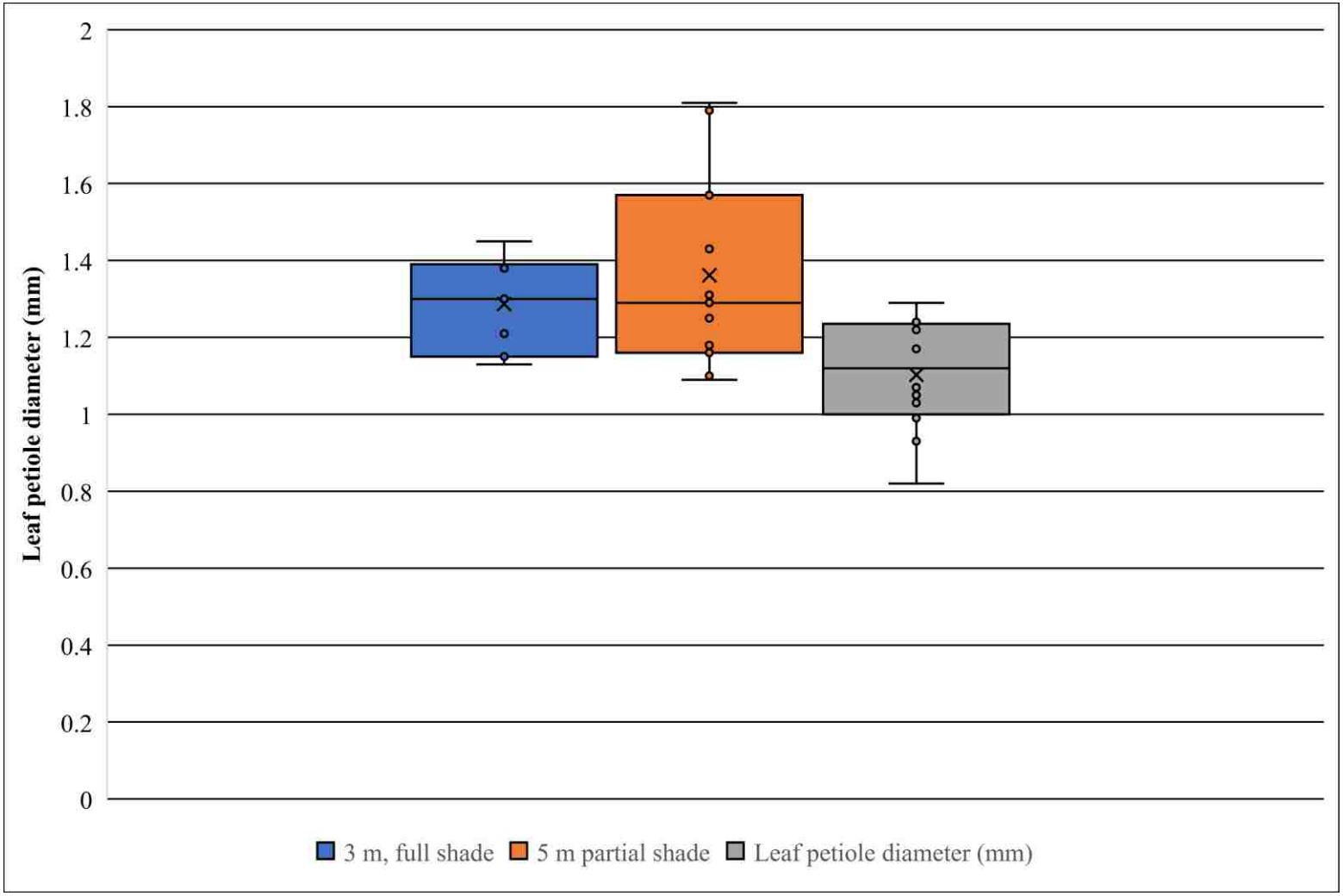


Figure 33. Leaf petiole diameter data for the three sets of samples of the single tree vegetation analysis. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 0.009855.

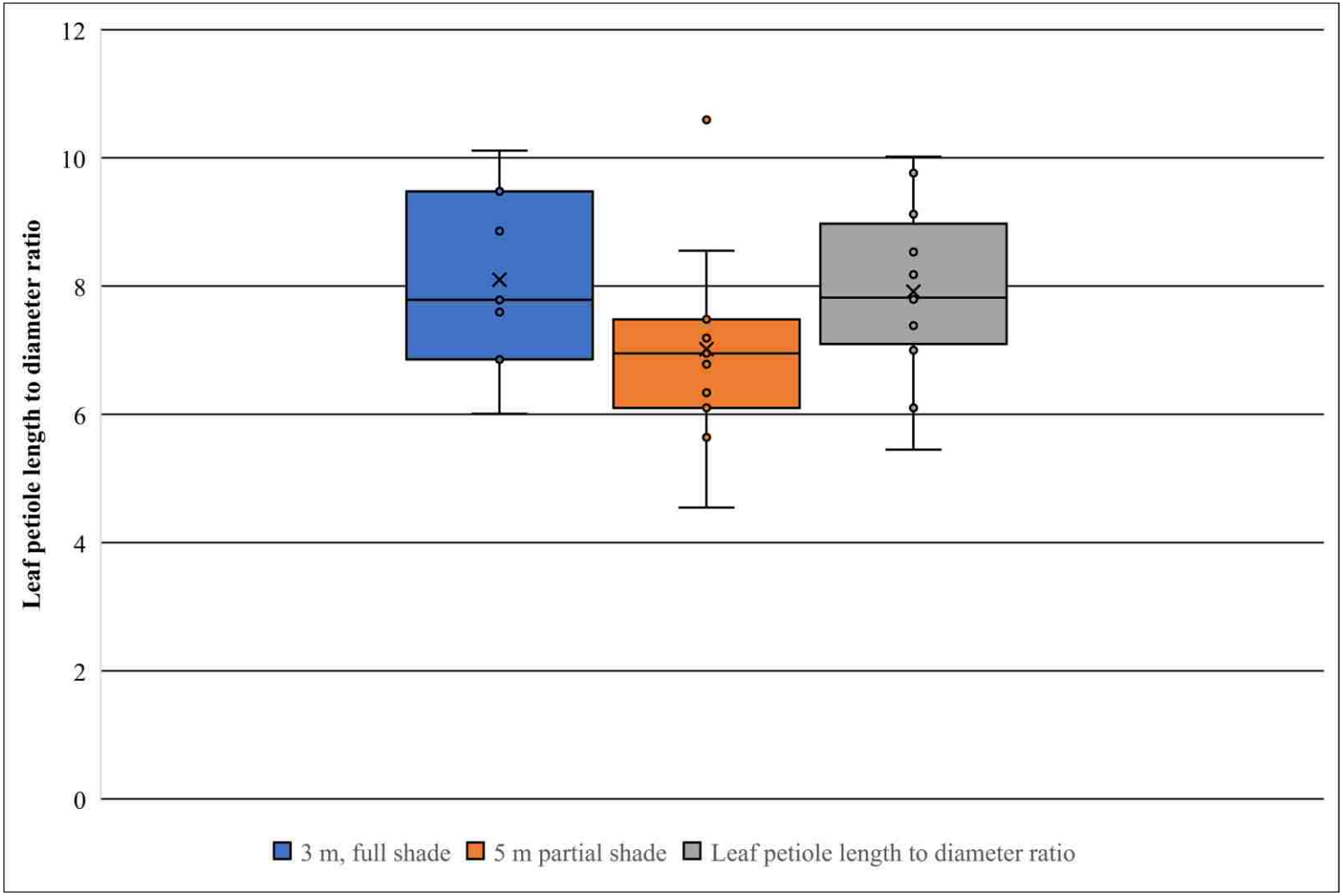


Figure 34. Leaf petiole length to diameter ratio data for the three sets of samples of the single tree vegetation analysis. This graph represents the middle 50%, range, median, and mean for each sample. p – value = 0.229672.

3. Abaxial midrib

The abaxial midrib of both varieties exhibited either a puberulent distribution of simple, solitary trichomes or was entirely glabrous. In *C. pumila* var. *pumila,* 93.3% of specimens exhibited simple, solitary trichomes and 6.7% of specimens were glabrous on the abaxial midrib. In *C. pumila* var. *ozarkensis*, 90.7% of specimens exhibited simple, solitary trichomes and 9.3% of specimens were glabrous on the abaxial midrib.

4. Adaxial leaf surface

Upon the adaxial surfaces of *C. pumila* var. *pumila* leaves, 86.6% of specimens were observed to have a very sparse distribution of simple, solitary trichomes, and 13.3% were entirely glabrous. Of the *C. pumila* var. *ozarkensis* specimens analyzed, 53.1% exhibited a very sparse distribution of simple, solitary trichomes, and 46.9% were entirely glabrous. Additionally, an unquantified, but relatively small portion of the adaxial surfaces of *C. pumila* var. *ozarkensis* leaves, especially those lacking maturity, were observed to exhibit bulbous trichomes. Bulbous trichomes were not observed in *C. pumila* var. *pumila* and were apparently lost with maturity in *C. pumila* var. *ozarkensis.*

5. Adaxial midrib

The adaxial midrib of both varieties exhibited either a puberulent distribution of simple, solitary trichomes or was entirely glabrous. In *C. pumila* var. *pumila,* 100% of specimens exhibited a puberulent distribution of simple, solitary trichomes on the adaxial midrib. In *C. pumila* var. *ozarkensis,* 87.5% of specimens exhibited a puberulent distribution of simple, solitary trichomes, whereas 12.5% of specimens were glabrous on the adaxial midrib.

6. Twig

The twigs of specimens analyzed of both varieties exhibited either stellate trichomes, simple, solitary trichomes, or were entirely glabrous. Pubescence appeared to be lost with age, as the only trichomes observed were on the twig growth from the season of collection. In *C. pumila* var. *pumila*, 6.7% of twigs exhibited stellate trichomes, 80% of twigs exhibited simple, solitary trichomes, and 20% of twigs were entirely glabrous. In *C. pumila* var. *ozarkensis*, 9.4% of twigs exhibited stellate trichomes, 18.8% of twigs exhibited simple, solitary trichomes, and 81.2% of twigs were entirely glabrous.

Discussion

This project had three main objectives. These were (1) to assess the status of *C. pumila* populations throughout the state of Arkansas, (2) to describe the ecology and natural history of the species as it occurs in Arkansas, and (3) to describe, quantify, and compare the vegetative morphology of the species' two varieties. These objectives were pursued because of a general lack of knowledge of the ecology of *C. pumila*, especially within Arkansas, as well as hypothesized differences between the ecology and morphology of the two varieties based upon personal observations in the field. The following subsections describe the implications of the results of this project's many analyses as they apply to the investigation of the research objectives, as well as future directions for research into the ecology of *Castanea pumila*.

A. Population status assessment

The assessment of Arkansas' state-wide *C. pumila* population was carried out to provide an update on the geographical distribution of the species' two varieties and to assess the health of

individual clones in terms of blight infection, growth form, and fruiting activity. Field data and specimen collections were accelerated such that time and growing season conditions were as close as possible to constant to minimize errors in comparisons between the two varieties.

1. Geographical distribution

The utilization of historical occurrence data in this project was invaluable to exploring and mapping the present-day distribution throughout the state. A total of 174 localities of historic occurrence of *C. pumila* var. *ozarkensis* were determined and mapped. Of these prospective localities of *C. pumila* var. *ozarkensis*, a great majority (139 total) were provided by the Buffalo National River (BNR). Similarly, a total of 46 prospective sites for *C. pumila* var. *pumila* were derived from historic occurrence data from both herbarium specimens and from the Arkansas Natural Heritage Commission (ANHC). It is important to note that a significant portion of the additional herbarium specimens available for each variety were not used in this project because the locality data were too vague and/or limited for proper determination. Success in re-visiting a known historically noted locality hinges upon a few major assumptions. These are – (1) that the original locality description was detailed enough to be located as much as a century later, (2) that legal access to the locality is achievable by the researcher, and (3) that minimal disturbance had occurred at the locality over time.

Most of the prospective sites for each variety were visited, and individuals of *C. pumila* var. *ozarkensis* and *C. pumila* var. *pumila* were observed at a total of 53 sites and 9 sites, respectively. For both varieties, clones were located at approximately 50% or fewer of the prospective sites derived from herbarium specimens. As stated, most of the available occurrence data for *C. pumila* var. *ozarkensis* were supplied by the Buffalo National River. These data consisted of GPS coordinates from relatively recent observations. Comparatively, the *C. pumila*

var. *pumila* occurrence data provided from the Arkansas Natural Heritage Commission consisted of little more than noted occurrence within several ANHC Natural Areas throughout the state, some of which were as large as 6,000 hectares.

The obvious difference in the rate of successful location of clones of each variety may be attributed to both the quality of occurrence data available in herbarium specimens and agency databases as well as the type of land available for field sites. Herbarium specimens vary greatly in locality data quality, regardless of age, and the highest success in this project was observed with specimens that listed coordinates, section references, or detailed road and field directions. The factors that led to high success with locating *C. pumila* var. *ozarkensis* from historic occurrences were the GPS coordinate data and the large amount of public land throughout the variety's range, including the BNR and the Ozark-St. Francis and Ouachita National Forests. These landholdings represent considerably large portions of *C. pumila* var. *ozarkensis* habitat that remain largely intact and easily accessible.

Comparatively, the overall lack of quality locality data from herbaria and from the ANHC yielded a low success rate in locating *C. pumila* var. *pumila* clones in the field. Additionally, public lands throughout the known historic range of *C. pumila* var. *pumila* are not nearly as abundant as in the northern portions of Arkansas. Many of the localities derived from herbarium specimens for this variety were located on private land and success in gaining permission to access the localities was very low. Considering the history of land fragmentation and widespread silviculture practices throughout southern Arkansas, it was hypothesized that much of the historic *C. pumila* var. *pumila* habitat had been significantly altered before the time of this project, which may indicate a reduction in population size and distribution.

The field observations of *C. pumila* var. *ozarkensis* and *C. pumila* var. *pumila* were mapped and showed considerable geographical clustering within each variety. Clones identified as *C. pumila* var. *ozarkensis* tended to occur within the Ozark Plateau and Ouachita Mountains portions of the Interior Highlands of Arkansas. In contrast, all clones identified as *C. pumila* var. *pumila* occurred south of clones of the other variety, being entirely restricted to within the Coastal Plain region of southern Arkansas. This distribution is consistent with that described by Tucker (1975).

Unfortunately, few clones were observed where the Interior Highlands and Coastal Plain converge, providing little evidence regarding the possible morphological intergradation between varieties as suggested by Tucker (1975). Two sites, the Mills Park Natural Area and the Lorance Creek Natural Area in Saline and Pulaski counties, respectively, may be the best representation of variety intergradation observed in this project. The clones at these sites exhibited vegetation more characteristic of *C. pumila* var. *ozarkensis* (relatively longer and wider leaves), but the habitat was more characteristic of *C. pumila* var. *pumila* (both sites were sandy barrens with gentle slopes). None of the clones at these sites bore fruit nor had they attained considerable size. Thus, they were considered clones of *C. pumila* var. *ozarkensis* because of the vegetation and overall lack of evidence otherwise.

2. Shoot data

A total of 366 shoots were analyzed for this project, 72 shoots of *C. pumila* var. *pumila* and 294 shoots of *C. pumila* var. *ozarkensis*. A total of 92% of the *C. pumila* var. *pumila* shoots were living at the time of observation, compared to 71% for *C. pumila* var. *ozarkensis*. Further, 35% of *C. pumila* var. *pumila* shoots exhibited evidence of blight infection, compared to more than 58% of *C. pumila* var. *ozarkensis* shoots. Fruiting was observed in a very low proportion of

shoots of each variety, with only 9.7% of *C. pumila* var. *pumila* shoots and 7.8% of *C. pumila* var. *ozarkensis* shoots showing evidence. The mean number of shoots per clone, the mean height of shoots, and the mean DBH of shoots each differed between varieties, but these differences were not statistically significant. Figure 35 displays photos of observed blight infection.

The data on living status and blight infection showed that a larger proportion of *C. pumila* var. *pumila* shoots were living and exhibited no indication of infection with the chestnut blight fungus than did shoots of *C. pumila* var. *ozarkensis*. These data are consistent with results reported by Graves (1950) that suggest shoots of *C. pumila* var. *pumila* are slightly less susceptible to infection by the chestnut blight fungus than are shoots of *C. pumila* var. *ozarkensis*. It is important to note that evidence of blight infection was most common on older shoots, especially dead shoots and relic logs. Due to the considerably smaller sample size of *C. pumila* var. *pumila* shoots in this project, paired with the higher proportion of relic logs observed for *C. pumila* var. *ozarkensis*, the author is reluctant to claim a difference in blight resistance based upon these data alone.

The lack of statistical significance between either the height, DBH, or number of shoots per clone for each variety suggests strong similarities in growth form between the two. These similarities are consistent with observations by Paillet (1993). The observed growth form was largely different than that of historic descriptions of each variety, with virtually no observed clones attaining their respective pre-blight stature. This observation is a significant contrast for *C. pumila* var. *ozarkensis* which was historically noted as a canopy level tree but was observed in this project to be entirely restricted to the subcanopy in the form of a small tree or a multi-shoot shrub. The observed similarity in growth form, paired with the low frequency of fruiting activity suggests that the clones remained heavily suppressed by the chestnut blight in 2018.

Figure 35. Examples of infection with the chestnut blight fungus. Left: A “canker”, or area of abnormal growth on a shoot that was attempting to heal from infection with the chestnut blight fungus. Right: Several shoots with cankers and cracked bark caused by infection with the chestnut blight fungus. (Photos by author).

B. Ecology

Data on the elevation, slope azimuth and inclination, and woody plant biodiversity of the sites surrounding each observed clone were recorded in an effort to quantify and describe the ecology and habitat preferences of each variety.

3. Physiographic data

The elevation, slope azimuth, and percent inclination of localities at which clones were located were recorded and compared. *Castanea pumila* var. *pumila* tended to occur at lower elevations and less steep slopes, whereas *C. pumila* var. *ozarkensis* tended to occur at higher elevations and on steeper slopes, by comparison. Although the differences observed between the means for each variety were statistically significant only for elevation. Most clones of *C. pumila* var. *pumila* occurred on slopes with a percent inclination of lower than 20%, but a small portion of clones were located at uncharacteristically steep sites that were dispersed along an eroded streambank. Likewise, most clones of *C. pumila* var. *ozarkensis* were observed on sites with a percent inclination of 60% or less, but a few outliers existed at bluff edges. No major correlation was observed in slope azimuth for either variety, and the differences observed were not statistically significant. No major correlation was observed in slope azimuth for either variety.

4. Woody plant associations

Each woody plant that occurred within 10 m of a clone was identified to at least the genus level and recorded for comparison between the two varieties. *Castanea pumila* var. *ozarkensis* clones were noted to occur with a larger number of taxa than those of *C. pumila* var. *pumila*, and a total of 21 taxa were present with clones of both varieties. The woody taxa that co-occurred with *C. pumila* var. *ozarkensis* with the greatest frequencies included *Quercus alba,*

Carya tomentosa, Cornus florida, Pinus echinata, and other clones of *C. pumila* var. *ozarkensis*. These data show that *C. pumila* var. *ozarkensis* tends to occur within the upland oak-hickory forests that are characteristic of the Interior Highlands of Arkansas. Comparatively, the woody taxa that co-occurred with *C. pumila* var. *pumila* with the greatest frequencies included *Ilex opaca, Nyssa sylvatica* var. *sylvatica, Quercus alba, Vitis* spp.*, and Hamamelis virginiana.* Woody plant taxa that were frequently observed in association with both varieties include *Quercus alba, Nyssa sylvatica* var. *sylvatica, Carya tomentosa, Vitis* spp.*, Pinus echinata,* and *Toxicodendron radicans.*

Although not well established in the literature, the habitat preference for both varieties of *C. pumila* can be extrapolated from the published habitat data of the most frequently occurring associated woody plant taxa. Noteworthy woody associates of *C. pumila* var. *pumila* included *Ilex opaca, Hamamelis virginiana, Carpinus caroliniana, Quercus nigra,* and *Carya cordiformis*. These taxa (each occurring with greater than 40% of *C. pumila* var. *pumila* clones in this project) are all noted to prefer mesic to submesic habitats as defined by Whittaker (1956, Moore 1992, Kirkman et al. 2007). None of these taxa occurred with significant frequency in association with *C. pumila* var. *ozarkensis* clones. Further, notable taxa that co-occurred frequently with *C. pumila* var. *ozarkensis* included *Quercus velutina, Juniperus virginiana,* and *Sassafras albidum,* which are each noted to occupy xeric sites in upland habitats (Whittaker 1956, Moore 1992). Overall, these woody plant associations suggest that *C. pumila* var. *pumila* tends to occupy more mesic habitats when compared to the more xeric habitat preferences of *C. pumila* var. *ozarkensis*.

C. Vegetative morphology

The vegetative morphology and microscopic anatomy of *C. pumila* was analyzed using morphometric techniques as well as compound light microscopy. These analyses were performed

in an effort to quantify any existing differences in the physical form of vegetation or within the anatomical structures on the vegetation.

1. Multivariate morphometric analysis

The morphometric analysis performed on the vegetation of three large samples of *C. pumila* generated a considerable amount of reliable data for comparison between varieties. The three samples were of leaves from *C. pumila* var. *ozarkensis* collected throughout Arkansas, *C. pumila* var. *pumila* collected throughout Arkansas, and *C. pumila* var. *pumila* collected from states far removed from this project. The most noteworthy observations derived from these data were the differences between leaf blade size as it corresponds to leaf blade shape. Leaf blade size was analyzed by simply measuring the length of the leaf blade from base to tip and the widest point of the leaf blade. Leaf blade shape was quantified by finding the ratio of leaf blade length to leaf blade width and was further explored by measuring where the widest point occurred relative to the leaf blade's length. Additional parameters of note included the number and spacing of margin teeth, as well as the petiole length and diameter.

The leaf blade size (both length and width) was shown to differ considerably between the two varieties, and a small difference was observed between *C. pumila* var. *pumila* samples from Arkansas versus those of the same variety from other states. The differences observed between the leaf blade length and width were statistically significant. Conversely, the leaf shape metrics (leaf blade length to width ratio and leaf blade widest point, percent of length) showed little differentiation between the samples, and the data for where the leaf blade's widest point occurred proportional to its length lacked statistical significance. In short, mature leaves of the three samples were shown to differ significantly in size, but despite the size difference, maintained a very consistent overall shape.

The other notable occurrences included the number of margin teeth per leaf blade, the spacing of margin teeth, and the petiole diameter, each of which exhibited statistically significant differences between varieties. Leaves of *C. pumila* var. *ozarkensis* were observed to have more marginal teeth than did either sample of *C. pumila* var. *pumila*. Additionally, the margin teeth of *C. pumila* var. *ozarkensis* were observed to be spaced farther apart than those of either sample of *C. pumila* var. *pumila*. Specimens of *C. pumila* var. *pumila* from outside of Arkansas exhibited a larger mean petiole length than either of the other two samples, yet specimens of *C. pumila* var. *ozarkensis* exhibited a larger mean petiole diameter.

2. Single tree vegetation analysis

A total of six specimens from three different canopy strata were collected from a single clone of *C. pumila* var. *ozarkensis* to investigate the variability in vegetative morphology that may exist within one single tree. These specimens underwent the same morphometric analysis as the specimens in the larger analysis, but the data from the single tree analysis were not used to represent *C. pumila* var. *ozarkensis* in any way as non-voucher specimens were purposefully collected. The specimens for this analysis were chosen to represent a gradient of sunlight availability. Full sun leaves were consistently smaller (in blade length and blade width) than partial shade leaves, and full shade leaves. This observed difference was statistically significant. Additionally, there existed little difference and no statistical significance as to where the leaf blade's widest point occurred proportional to its length for the three samples. These data again suggest that despite the varying sizes of leaf blades observed in *C. pumila*, leaf blade shape is highly consistent. Overall, these data emphasized the importance of consistent and representative voucher specimen collection when vegetative morphology is to be analyzed and compared.

3. Microscopic anatomy

Compound light microscopy was used to analyze the type, density, and distribution of trichomes on the *C. pumila* specimens collected from Arkansas. Areas of interest within the specimens were the abaxial surface and midrib, adaxial surface and midrib, margins, and twig. Numerous leaves were observed for each specimen, and characteristics were noted. No correlation existed between these data, as many inconsistencies and considerable variation were observed within specimens and especially within varieties, and no major differences were observed between varieties.

A total of three types of trichomes were observed in this analysis. These were (1) simple, (2) stellate, and (3) bulbous. Simple and stellate trichomes were observed inconsistently across the abaxial and adaxial surfaces of samples of both varieties. Bulbous trichomes were observed only on the adaxial surface of immature *C. pumila* var. *ozarkensis* leaves and appeared to be lost at maturity. For both varieties, stellate trichomes were observed only on the leaves' abaxial surface and appeared to be more prominent on younger leaves (those closest to the terminal bud), and on full sun leaves. Where observed, stellate trichomes occurred in densities ranging from puberulent to tomentose. Puberulent densities of simple, solitary trichomes were observed on the adaxial and abaxial surfaces, margins, and twigs of both varieties. Several leaves of both varieties were entirely glabrous, and the absence of trichomes was observed in each of the areas analyzed. While these data exhibited no major correlations, the results were congruent with data published by Hardin and Johnson (1985).

D. *Castanea pumila* in Arkansas historically

Historically, as many as four taxa of *Castanea* were described as native to Arkansas. These were *C. arkansana* Ashe (an endemic of five counties in northwest Arkansas), *C. ozarkensis* Ashe, *C. pumila Ashei* Sudworth, and *C pumila Margarette* Ashe (Sudworth 1922, Ashe 1922, 1923, 1924, Moore 1941, Demaree 1943). Tucker (1975) combined *Castanea arkansana* and *C. ozarkensis* into *Castanea pumila* (L.) Mill. var. *ozarkensis* (Ashe) G.E. Tucker. Tucker (1975) also combined *C. ashei, C. margarette,* and numerous other taxa occurring outside of Arkansas, into *Castanea pumila* (L.) Mill. var. *pumila* G.E. Tucker, on the basis of intergrading morphologies.

Few data are available on the importance and abundance of the chinquapins as they occurred throughout the forests of Arkansas before the 1950's arrival (Paillet 2012) of the chestnut blight fungus. Virtually all the published data on pre-blight chinquapin in Arkansas pertains to *C. pumila* var. *ozarkensis.* Chapman et al. (2006) presented data from a 1934 survey in north-central Arkansas, noting *C. ozarkensis* densities of 15.7 trees/ha in the understory stratum and 0.9 trees/ha in the overstory stratum. Basal area from these 1934 surveys were 0.6 m^2/ha and 0.7 m^2/ha at the understory and overstory strata, respectively. Paillet (1993, 2012) noted that the distribution of the original blight killed trees in Arkansas was clustered and densities were were relatively low, approximately 1 tree per ha. Despite their apparently uncommon distribution historically, chinquapin trees held socioeconomic value like that of the American chestnut. Chinquapins were historically important to both man and wildlife because of their bountiful nut crop and rot resistant lumber that was ideal for fences and railroad ties (Payne et al. 1994, Dane and Hawkins 1999).

E. *Castanea pumila* in Arkansas today

This project, as well as the works of both Paillet (1993, 2012) and Johnson (1985, 1988), have demonstrated how the chestnut blight fungus has had a significant impact on the ecology and distribution of the populations of *Castanea pumila* throughout its range. Infection with the chestnut blight continues to heavily suppress clones and causes them to take on unnatural growth forms. Clones of both varieties of *C. pumila* are so heavily suppressed that their appearance in the field tends to be very similar. No living clones of *C. pumila* var. *ozarkensis* were observed that achieved a size like that of the historical descriptions, as virtually all were observed to exist as as multiple, small-diameter shoots with heights restricted to the subcanopy. Most clones of *C. pumila* var. *pumila* were also observed to be growing in the form of multi-shoot shrubs at the subcanopy level, with the few exceptions being limited to light gaps and edges.

Modern studies of density and distribution of clones in Arkansas have shown that chinquapin is still locally abundant, with populations clustering in areas where remnant logs and stumps indicate pre-blight occurrence (Paillet 1993). However, significant reductions in density, and basal area in the forests of Arkansas following the chestnut blight fungus were observed. A 2002 survey by Chapman et al. (2006) noted densities of *C. pumila* var. *ozarkensis* at the same sites surveyed in 1934 to be 0.2 trees/ha at the overstory stratum and 2.7 trees/ha at the understory stratum, and basal areas of 0.02 m^2/ha and 0.01 m^2/ha at both strata, respectively. These reductions reiterate the extent of suppression that clones of *Castanea pumila* experience in modern times as the blight persists.

The relatively low importance and historically clustered abundance of chinquapin would suggest that the downfall brought on by the chestnut blight fungus likely had localized impacts on the dynamics and composition of the forests of Arkansas, similar to – but not as severe as –

the widespread changes observed following the downfall of the American chestnut. Nonetheless, the downfall of chinquapin ultimately meant the total loss of preferred forage for wildlife and man, as well as an economically important source of lumber from the region. The absence of chinquapin nuts undoubtedly shifted the forage by small mammals to other native nuts, potentially impacting the population ecology of numerous other taxa.

Summary and Conclusions

Around the turn of the twentieth-century a strong pathogen, the chestnut blight fungus (*Cryphonectria parasitica*), was accidentally introduced into the expansive and diverse forests of eastern North America. The fungus, a parasitic specialist of trees of the genus *Castanea*, rapidly spread throughout the ranges of North America's *Castanea* natives. The presence of the chestnut blight fungus meant catastrophic changes for the forest communities of the region as the continental population was nearly extirpated. Following this catastrophe, the scientific eye focused on the most socioeconomically important species of the group, the American chestnut (*Castanea dentata*). In the shadow of the American chestnut, the other *Castanea* natives, the chinquapins, were largely overlooked, leaving significant gaps in the knowledge of their ecology and natural history that remain today.

A. Conclusions

During two field seasons in Arkansas, data were collected to assess the health status, geographical distribution, ecology, and vegetative morphology of *Castanea pumila* populations throughout the state. Localities of historical occurrence throughout the state were visited and field sites were established where clones were successfully located. For each shoot of the clones

observed, data were taken on the shoot's size (height and DBH), health status, blight infection, and fruiting activity. For each site, physiographic data and a tally of the woody plant taxa were taken to describe the site ecology. Also, where permitted, voucher specimens of mature leaves were collected, pressed for drying, and were later subjected to a multivariate morphometric analysis.

The data collected on the distribution and health status of the clones observed were compiled by variety for an overall assessment of the state-wide population status and distribution for each variety. Congruent with historical range data, clones of *C. pumila* var. *ozarkensis* were observed throughout the Interior Highlands physiographic region of western-central, northwestern, and north-central Arkansas, whereas clones of *C. pumila* var. *pumila* were observed within the Coastal Plain region of southwestern and south-central Arkansas.

For both varieties, the majority of shoots observed were alive at the time of observation, with *C. pumila* var. *pumila* having the greater proportion of living shoots. A smaller proportion of *C. pumila* var. *pumila* shoots exhibited evidence of infection with the chestnut blight fungus than did shoots of *C. pumila* var. *ozarkensis*. These data support the hypothesized relative heightened resistance to the chestnut blight fungus exhibited by *C. pumila* var. *pumila*. No significant difference in the number of shoots per clone, the height of shoots, nor the DBH of shoots was observed between varieties. These results quantify the remarkable similarities observed in growth form of clones of each variety as these clones were heavily suppressed by the chestnut blight fungus.

Based upon the observed geographical divergence between the two varieties, it was hypothesized that site ecology also differed greatly, which could indicate differing habitat

preferences between varieties. The data collected on site ecology were subjected to numerous analyses to identify minute differences between the habitat preferences and woody plant associations of each variety. Physiographic parameters included – elevation, slope azimuth, and percent inclination of slope. Elevation was the only physiographic parameter to yield a significant difference between varieties. These data suggested that *C. pumila* var. *ozarkensis* tended to occur at higher elevations and on steeper slopes than did *C. pumila* var. *pumila*.

The woody plant associates for each variety were tallied, and a larger total number of taxa were observed in association with *Castanea pumila* var. *ozarkensis*. The three most frequent taxa occurring at *C. pumila* var. *ozarkensis* sites were *Quercus alba, Carya tomentosa, and Cornus florida*. The three most frequent taxa occurring at *C. pumila* var. *pumila* sites were *Ilex opaca, Nyssa sylvatica* var. *sylvatica,* and *Quercus alba*. The woody plant association data for each variety suggested that *C. pumila* var. *ozarkensis* clones were more frequently associated with taxa that are known to prefer xeric sites, and *C. pumila* var. *pumila* clones were more frequently associated with taxa that are known to prefer mesic sites.

A multivariate morphometric analysis was performed on leaves of each variety from voucher specimens collected at sites throughout the state and from a sample of herbarium specimens of *C. pumila* var. *pumila* collected outside of Arkansas. Significant differences between varieties were observed for the following parameters – leaf blade length, leaf blade width, leaf blade length to width ratio, petiole diameter, the number of margin teeth, and the spacing of margin teeth. Most notably, *C. pumila* var. *ozarkensis* exhibited consistently longer and wider leaves than did either of the samples of *C. pumila* var. *pumila*. However, despite the size difference observed between varieties, the leaf length to width ratio and overall leaf blade

shape remained relatively consistent. Leaf size was also demonstrated to vary largely within a single tree depending upon the forest strata from which the collection was made.

The microscopic anatomy of leaves was investigated to analyze the type, density, and distribution of trichomes on the leaf surfaces of each variety. Three types of trichomes were observed – simple, stellate, and bulbous. Simple and stellate trichomes were observed in puberulent to tomentose densities on a selection of leaves of both varieties, but bulbous trichomes were only observed in a selection of *C. pumila* var. *ozarkensis* leaves. Several leaves from each variety were entirely glabrous on the adaxial and/or abaxial leaf surface(s). Large variation was observed within single specimens, and within varieties, with no real correlation between varieties.

This project demonstrated that Arkansas' *C. pumila* populations were observed to be sustaining and persisting despite being highly suppressed by the chestnut blight fungus. From the data generated during this project, several differences were observed between the two varieties of *C. pumila* as they occur throughout the state of Arkansas. Most notable are the differences that exist between the distribution, site ecology, habitat preference, and vegetative morphology of the two varieties. Although not every analysis performed supported the author's hypothesis, all results supported the overarching goal of the project which was to advance the knowledge of these forgotten trees.

B. Future research

There is still much to learn about *Castanea pumila* throughout North America. More in depth comparative studies within and between varieties should be performed to challenge the validity of the current taxonomic classification. Additionally, researchers should continue to

pursue a cure for pathogenic effects of the chestnut blight fungus and release these trees from suppression.

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Appendices

Appendix A. Locations where *Castanea pumila* clones were not located despite noted historical occurrence data and/or significant effort.

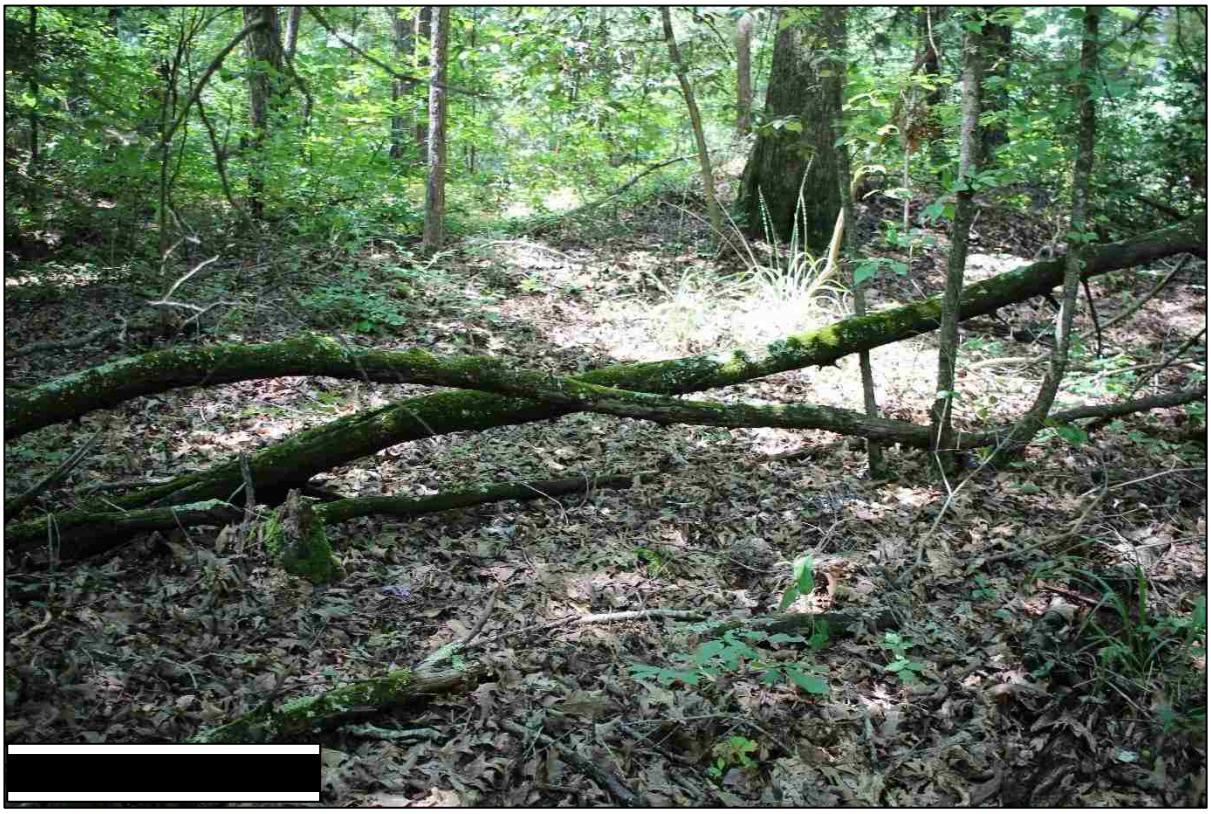
***Castanea pumila* variety**	**General location name**	**Specific locality**	**Historical occurrence?**
ozarkensis	Devils Den State Park	Yellow Rock Trail, Butterfield Trail	No
ozarkensis	Ozark - St. Francis National Forest	Clifty Hollow	Yes
ozarkensis	Ozark - St. Francis National Forest	White Oak Mountain overlook	No
ozarkensis	Ozark - St. Francis National Forest	Longpool Rec. Area	Yes
ozarkensis	Ozark - St. Francis National Forest	Richland Creek Rec. Area	Yes
ozarkensis	Buffalo National River	Boxley Valley, edge of Co. Rd. 5	Yes
ozarkensis	Mount Nebo State Park	Non-specific	Yes
ozarkensis	Mount Magazine State Park	Near Brown Springs	Yes
ozarkensis	Ouachita National Forest	McGraw Mountain	Yes
ozarkensis	Ouachita National Forest	Sugartree Mountain	Yes
pumila	Lake Dardnelle State Park	Near old boat ramp	Yes
pumila	Saline County	Danville Rd. near Middle Fork	Yes
pumila	Lake Catherine State Park	Multiple Trails	No
pumila	Cossatot River State Park	Non-specific	Yes
pumila	Dierks Lake	Horshoe Bend campground	Yes
pumila	Ouachita National Forest	Brush Heap Mountain	Yes
pumila	Lorance Creek Natural Area	Rolling pine woods	Yes
pumila	Mills Park Natural Area	Non-specific	Yes
pumila	Alleene, AR	Hwy. 234 & R.R.	Yes
pumila	Millwood Lake State Park	Woods behind maintainance bldg.	Yes
pumila	Necatoch Ravines Natural Area	Non-specific	Yes
pumila	Patmos, AR	N of 355, 0.5 mi E of county line	Yes
pumila	White Oak Lake State Park	Non-specific	Yes
pumila	Doddridge, AR	Around Macedonia Baptist Church	Yes
pumila	Moro Bay State Park	Non-specific	Yes
pumila	Moro Big Pine Natural Area	Non-specific	Yes
pumila	Calion, AR	3.5 mi from Ouachita River Bridge	Yes
pumila	Harrell, AR	1.1 W of Ark. 160	Yes
pumila	Junction City, AR	Spring-fed area near Blanchard Spgs.	Yes
pumila	North Crossett, AR	S side of Lake Georgia Pacific	Yes
pumila	Warren Prairie Natural Area	Non-specific	Yes
pumila	Pinehill, AR	6 mi SW of Monticello	Yes
pumila	Kingsland Prairie Natural Area	Non-specific	Yes
pumila	Taylor Woodlands Natural Area	Non-specific	Yes
pumila	Devils Backbone Natural Area	Non-specific	Yes

Appendix B. Additional photographs of *C. pumila* var. *ozarkensis*. (Photos by author).

Appendix B. Continued. Additional photographs of *C. pumila* var. *pumila*. (Photos by author).

Appendix C. Relic logs of *C. pumila* var. *ozarkensis.*

Appendix C. Continued. Relic logs of *C. pumila* var. *pumila*. (Photos by author).



Appendix D. Raw multivariate morphometric analysis data.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
pumila	3	1	136.12	59.31	66.14	3.22	1.07	11	12
pumila	3	2	104.25	42.43	41.93	3.7	0.9	13	11
pumila	3	3	86.35	37.11	38.17	2.27	0.95	11	11
pumila	3	4	83.75	43.59	44.41	3.06	0.97	10	10
pumila	3	5	104.35	58.51	51.23	3.56	1.09	10	10
pumila	3	6	122.39	58.13	60.22	2.62	0.88	12	11
pumila	3	7	109.55	51.65	48.93	3.76	0.96	10	10
pumila	4.1	1	120.11	58.81	57.59	3.78	1.32	15	12
pumila	4.1	2	114.35	58.19	59.99	3.34	1.15	15	16
pumila	4.1	3	74.11	39.85	43.22	2.77	1.05	13	12
pumila	4.1	4	97.88	49.44	43.95	4.12	0.94	12	12
pumila	4.1	5	90.84	51.82	41.47	3.54	1.13	13	12
pumila	4.1	6	117.57	66.71	56.87	3.29	1.19	14	14
pumila	4.2	1	98.77	43.35	41.49	4.54	1.13	12	12
pumila	4.2	2	85.86	36.82	46	4.42	0.83	12	13
pumila	4.2	3	93.97	36.81	33.05	4.34	0.82	10	11
pumila	4.2	4	99.9	45.52	52.01	4.2	1.02	16	14
pumila	4.2	5	75.25	37.67	39.15	4.27	1.26	14	13
pumila	4.2	6	74.73	37.77	35.48	4.16	0.82	16	15
pumila	5	1	101.82	43.61	46.66	4.34	0.73	12	13
pumila	5	2	106.13	40.52	54.97	3.88	0.61	14	12
pumila	5	3	131.69	51.55	65.22	4.6	0.79	12	14
pumila	5	4	149.43	65.63	76.01	5.86	0.89	13	16
pumila	5	5	131.76	57.48	56.86	4.67	0.71	15	15
pumila	5	6	117.29	51.18	66.59	4.27	0.8	15	12
pumila	6	1	104.68	45.29	55.47	4.03	0.69	12	10
pumila	6	2	100.75	44.55	43.1	3.49	0.66	13	15

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
pumila	6	3	93.32	41.04	41.33	3.6	0.7	13	12
pumila	6	4	96.11	39.67	42.14	3.37	0.68	12	13
pumila	6	5	93.07	37.47	37.49	4.12	0.73	12	13
pumila	6	6	88.22	40.19	38.09	3.32	0.7	11	13
pumila	6	7	92.71	37.85	44.59	4.08	0.63	12	14
pumila	7	1	140.46	59.38	58.62	5.82	0.97	13	15
pumila	7	2	113.73	50.04	47.38	5.44	0.81	12	13
pumila	7	3	121.71	48.27	47.92	4.82	0.72	15	12
pumila	7	4	133.26	54.59	68.25	4.73	0.84	12	14
pumila	7	5	148.13	61.3	72.65	5.43	0.91	15	12
pumila	7	6	146.58	58.53	77.31	4.97	1.02	16	16
pumila	7	7	134.42	49.45	64.61	5.61	0.82	12	15
pumila	7	8	120.01	45.96	62.49	5.24	0.87	14	12
pumila	8	1	122.65	67.06	59.61	4.41	0.82	14	14
pumila	8	2	138.95	59.25	63.59	3.72	0.88	14	11
pumila	8	3	101.23	57.91	48.32	3.37	1.04	11	12
pumila	8	4	123.16	51.63	49.78	3.4	1.01	11	10
pumila	8	5	102.14	50.9	40.8	3.91	0.72	16	15
pumila	8	6	103.61	51.08	45.23	2.62	0.82	17	17
pumila	8	7	110	55.35	50.24	3.89	0.98	13	12
pumila	8	8	129.87	56.83	56.52	4.6	0.96	14	18
pumila	8	9	135.87	66.62	57.12	4.09	1.02	16	14
pumila	9	1	117.24	61.56	53.93	5.66	0.95	13	14
pumila	9	2	134.49	60.58	53.25	6.23	0.8	16	14
pumila	9	3	144.23	68.92	65.53	5.31	0.87	13	15
pumila	9	4	139.18	62.01	60.07	6.4	0.93	15	14

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
pumila	9	5	149.89	67.32	71.06	7.15	0.93	14	17
pumila	9	6	165.31	79.68	85.42	6.55	1.13	16	14
pumila	9	7	174.39	86.64	81.47	6.1	1.1	14	15
pumila	2018 - 14.1	3	81.52	31.87	37.54	3.95	0.76	11	11
pumila	2018 - 14.1	5	106.03	44.93	46.55	5.93	0.73	13	14
pumila	2018 - 14.1	6	113.41	52.6	52.51	5.34	0.88	13	13
pumila	2018 - 14.1	7	116.69	50.28	47.46	6.18	0.63	13	13
pumila	2018 - 14.1	8	123.64	44.84	56.57	5.66	0.69	12	14
pumila	2018 - 14.2	1	89.25	38.48	39.47	5.48	0.9	12	11
pumila	2018 - 14.2	2	82.24	38.8	33.32	5.14	0.71	13	13
pumila	2018 - 14.2	3	105.27	48.54	49.53	4.2	0.79	16	15
pumila	2018 - 14.2	5	119.1	44.58	57.99	5.45	0.83	14	14
pumila	2018 - 14.2	6	120.65	53.34	60.59	5.2	0.73	17	16
pumila	2018 - 14.2	7	148.99	62.56	68.92	5.98	1.13	16	15
pumila	2018 - 14.2	8	120.79	53.95	59.11	4.67	0.8	17	16
pumila	2018 - 15	2	94.47	52.94	51.94	4.25	0.82	11	12
pumila	2018 - 15	3	93.21	49.96	45.76	3.94	1.14	11	12
pumila	2018 - 15	4	83.53	42.4	42.61	3.53	1.01	10	10
pumila	2018 - 15	5	100.22	51.42	51.35	3.95	1.1	12	12
pumila	2018 - 15	6	112.23	56.24	55.33	4.08	0.96	13	12
pumila	2018 - 15	8	102.92	50.68	51	4.25	0.86	12	12
pumila	2018 - 15	9	118.42	62.75	55.5	3.35	1.07	12	14
pumila	2018 - 15	10	123.31	65.69	59.53	4.27	1.12	13	12
pumila	2018 - 17	1	69.67	25.75	28.42	6.66	0.94	12	12
pumila	2018 - 17	2	113.69	37.63	46.63	5.19	0.85	13	13
pumila	2018 - 17	4	118.48	40.33	47.17	4.42	0.97	18	14

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
pumila	2018 - 4	1	110.95	52.17	49.23	4.83	1	15	15
pumila	2018 - 4	2	113.27	54.96	49.91	4.26	1.22	16	16
pumila	2018 - 4	3	124.21	62.57	60.59	4.94	1.11	14	15
pumila	2018 - 4	4	121.77	48.56	51.13	5.13	0.87	14	13
pumila	2018 - 4	5	129.11	62.66	61.23	4.97	1.03	14	15
pumila	2018 - 4	6	90.61	41.66	42.9	5.28	0.8	11	11
pumila	2018 - 6	1	87.62	34.38	42.03	3.89	0.79	13	13
pumila	2018 - 6	2	101.74	44.43	31.7	4.32	0.84	14	15
pumila	2018 - 6	3	119.06	50.49	57.48	3.81	1.27	15	14
pumila	2018 - 6	4	92.95	37.36	39.39	3.91	0.82	15	15
pumila	2018 - 6	5	108.54	44.93	47.53	4.54	0.93	15	15
pumila	2018 - 6	6	129.29	57.03	50.93	3.6	1.34	17	18
pumila	2018 - 6	7	140.07	56.87	63.79	4.42	1.13	16	16
pumila	2018 - 6	8	127.21	41.54	57.94	3.42	1.08	16	17
pumila	2018 - 8	1	69.21	32.63	33.72	4.92	0.96	10	11
pumila	2018 - 8	2	79.55	37.57	35.03	4.26	0.72	13	13
pumila	2018 - 8	3	87.82	39.41	38.57	3.34	0.91	13	12
pumila	2018 - 8	4	101.42	45.81	47.82	4.97	0.87	14	15
pumila	2018 - 8	5	113.1	55.87	57.9	3.33	0.98	16	16
pumila	2018 - 8	7	70.54	34.11	30.54	3.88	0.84	11	10
pumila	2018 - 8	8	90.34	40.84	43.29	4.9	0.98	12	12
pumila	2018 - 8	9	100.88	48.44	39.3	3.86	0.84	16	16
pumila	2018 - 8	10	121.56	56.44	58.65	3.4	1.11	16	16
pumila	2018 - 8	11	82.77	35.73	40.8	3.8	0.72	12	13
pumila	2018 - 8	12	80.97	31.98	33.84	4.93	0.89	13	13
pumila	2018 - 8	13	110.13	55.57	54.73	4.43	1.2	14	13

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
pumila	2018 - 8	15	84.22	33.87	39.8	3.7	1.38	13	13
pumila	2018 - 8	16	107.28	42.63	49.63	5.21	0.84	15	15
pumila	2018 - 8	17	112.94	52.52	50.62	4.7	1.02	16	15
pumila	2018 - 8	18	138.37	64.86	64.46	4.4	1.07	17	18
pumila	2018 - 8	19	125.04	59.74	56.33	4.17	1.27	17	16
pumila	2018 - 9	1	74.07	41.67	40.41	3.32	0.79	12	12
pumila	2018 - 9	2	108.38	52.81	48.38	4.7	1.12	10	9
pumila	2018 - 9	3	117.78	62.21	64.83	4.63	1.2	12	12
pumila	2018 - 9	5	91.42	42.92	52.58	4.31	0.81	10	9
pumila	2018 - 9	8	81.85	38.73	41.53	4.24	0.64	11	9
pumila	2018 - 9	10	105.7	50.41	57.68	3.19	1.04	12	13
pumila	2018 - 9	11	124.97	61.44	59.52	5.25	1.1	13	14
pumila	2018 - 9	12	130.67	66.62	64.87	5.67	1.03	12	13
pumila	2018 - 9	13	127.08	56.03	57.03	4.53	1.29	11	11
ozarkensis	1.1	1	173.23	69.3	82.14	7.64	1.92	15	15
ozarkensis	1.1	2	183.48	66.15	94.04	8.92	1.58	17	18
ozarkensis	1.1	5	157.64	51.57	67.73	6.84	1.4	16	14
ozarkensis	1.1	6	158.97	47.72	78.47	7.97	1.42	17	18
ozarkensis	1.2	2	179.03	72.45	82.66	8.3	1.4	14	14
ozarkensis	1.2	4	187.67	71.1	72.22	7.23	1.55	18	15
ozarkensis	1.2	5	174.21	67.9	81.83	7.05	1.31	17	16
ozarkensis	1.2	6	167.36	49.38	83.95	7.02	1.2	18	17
ozarkensis	2.1	2	186.69	58.5	88.46	10.83	1.41	17	19
ozarkensis	2.1	3	187.98	63.55	82.84	11.4	1.57	19	17
ozarkensis	2.1	4	191.11	57.99	87.79	11.35	1.32	18	18
ozarkensis	2.1	5	177.37	54.95	84.62	10.11	1.54	17	16

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
ozarkensis	10	1	113.35	54.11	55.2	6.07	0.99	12	11
ozarkensis	10	2	158.35	68.96	77.58	6.76	1.12	14	14
ozarkensis	10	3	163.4	72.13	74.75	7.76	1.14	19	15
ozarkensis	10	4	164.23	61.32	70.96	4.89	1.09	14	15
ozarkensis	10	5	166.91	66.89	78.26	6.45	1.09	18	15
ozarkensis	10	6	181.47	73.65	78.51	5.95	1.14	15	16
ozarkensis	10	7	161.85	59.05	76.42	4.71	1.04	17	16
ozarkensis	11	1	120.37	47.02	68.01	5.29	1.17	12	13
ozarkensis	11	2	143.35	56.42	93.29	7.2	1.04	15	15
ozarkensis	11	3	159.26	63.8	75.5	5.86	1.2	15	16
ozarkensis	11	4	158.5	61.72	73.54	5.59	1.03	19	16
ozarkensis	11	5	146.22	56.35	73.74	6.25	1.24	15	15
ozarkensis	11	6	152.78	63	67.99	7.42	1.19	15	14
ozarkensis	11	7	190.51	72.69	98.82	6.74	1.54	18	16
ozarkensis	11	8	177.98	69.39	95.8	6.33	1.32	15	17
ozarkensis	11	9	176.88	65.03	90.28	6.11	1.47	18	14
ozarkensis	11	10	175.6	65.68	89.29	6.65	1.11	13	16
ozarkensis	11	11	156.44	57.36	87.41	7.57	1.1	16	17
ozarkensis	12	1	131.42	55.47	60.33	4.89	1.22	12	13
ozarkensis	12	2	129.82	47.52	56.26	5.44	0.88	14	13
ozarkensis	12	3	168.31	65.44	77.4	5.88	1.03	15	16
ozarkensis	12	4	163.19	59.44	74.13	5.9	1.08	13	14
ozarkensis	12	5	201.11	73.29	103.56	6.03	1.47	14	16
ozarkensis	12	6	195.13	75.73	83.8	5.87	1.22	14	13
ozarkensis	13	1	139.44	57.65	62.61	6.35	1.11	15	14
ozarkensis	13	2	145.49	63.54	68.68	6.01	1.01	13	15

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
ozarkensis	13	3	159.23	68.34	80.26	5.67	1.04	15	13
ozarkensis	13	4	151.66	54.6	65.61	5.39	0.98	12	13
ozarkensis	14	1	183.22	80.72	88.21	7.85	1.09	17	15
ozarkensis	14	2	189.74	78.81	94.51	8.27	1.32	19	16
ozarkensis	14	3	164.49	65.79	82.1	7.92	1.27	12	12
ozarkensis	14	4	119.66	58.79	42.56	7.62	1.03	14	14
ozarkensis	15	1	102.97	48.11	50.06	5.63	1.11	11	11
ozarkensis	15	2	116.55	47.26	49.93	5.42	1.01	13	11
ozarkensis	15	3	140.91	64.3	62.13	7.01	1.04	12	13
ozarkensis	15	4	140.47	60.22	63.83	6.54	1.06	12	12
ozarkensis	15	5	118.51	56.65	59.51	5.36	1.11	13	11
ozarkensis	15	6	137.7	61.54	65.82	8.15	1.27	11	13
ozarkensis	15	7	142.02	66.39	66.74	6.66	1.16	15	13
ozarkensis	15	8	150.32	69.67	71.79	7.14	1.15	11	13
ozarkensis	15	9	148.46	69.78	81.43	5.51	1.34	11	9
ozarkensis	17	1	162.78	77.31	84.89	7.27	1.43	14	13
ozarkensis	17	2	168.82	73.55	85.21	9.22	1.28	17	17
ozarkensis	17	3	196.14	85.38	94.72	7.87	1.46	18	16
ozarkensis	17	4	112.23	54.22	42.6	6.97	1.05	11	12
ozarkensis	17	5	138.96	66.71	62.6	7.18	1.73	13	14
ozarkensis	17	6	136.08	58.68	64.22	9.87	1.61	15	14
ozarkensis	17	7	156.28	61.28	73.63	9.94	1.58	17	16
ozarkensis	17	8	204.02	79.5	100.51	12.3	1.66	22	22
ozarkensis	17	9	196.96	71.26	104.3	11.57	1.47	22	21
ozarkensis	18	1	154.62	60.52	68.58	7.74	1.18	15	16
ozarkensis	18	2	162.13	66.44	72.15	6.48	1.24	18	20

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
ozarkensis	18	3	148.01	57.75	67.6	7.11	1.04	17	15
ozarkensis	18	4	190.09	67.54	78.8	8.05	1.39	19	17
ozarkensis	18	5	195.4	80.29	109.05	8.57	1.32	18	20
ozarkensis	18	6	189.9	75.68	89.12	6.37	1.26	15	17
ozarkensis	19	1	146.82	56.64	66.7	8.12	0.89	14	14
ozarkensis	19	2	118.79	52.57	60.32	5.74	1	13	14
ozarkensis	19	3	148.04	56.94	84.58	7.84	1.34	16	15
ozarkensis	19	4	152.07	66.55	67.45	6.21	1.07	15	15
ozarkensis	19	5	123.37	48.9	55.5	4.41	0.97	15	14
ozarkensis	19	6	151.07	59.74	73.98	8.69	1.13	18	18
ozarkensis	19	7	149.78	67.27	76.29	6.81	1.09	18	18
ozarkensis	19	8	170.92	73.27	82.37	8.03	1.24	16	18
ozarkensis	19	9	162.25	65.66	82.99	7.32	1.37	14	15
ozarkensis	20	1	118.61	66.81	70.22	8.66	1.24	11	11
ozarkensis	20	2	164.23	82.53	66.44	11.61	1.28	15	15
ozarkensis	20	3	168.93	86.07	83.51	11.36	1.37	16	12
ozarkensis	20	4	181.53	76.58	84.47	9.48	1.25	13	17
ozarkensis	20	5	170.92	75.03	93.09	10.19	1.43	15	14
ozarkensis	20	6	163.72	64.75	76.19	9.11	1.2	13	15
ozarkensis	22	1	159.67	71.82	78.29	5.96	1.13	16	14
ozarkensis	22	2	164.81	78.29	75.39	6.23	1.29	11	13
ozarkensis	22	3	177.91	85.79	82.91	6.36	1.3	15	15
ozarkensis	22	4	187.58	86.9	96.4	7.06	1.59	14	15
ozarkensis	24	1	116.52	72.79	54.17	6.1	0.8	12	16
ozarkensis	24	2	165.25	82.75	84.59	8.66	1.01	16	18
ozarkensis	24	3	204.3	94.46	98.99	11.24	1.14	16	17

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
ozarkensis	24	4	211.89	104.47	100.36	8.37	1.08	22	18
ozarkensis	24	5	224.62	99.79	98.78	9.39	1.45	17	16
ozarkensis	25	1	147.26	77.87	82.35	7.92	0.79	16	14
ozarkensis	25	2	164.08	72.24	64.57	7.94	0.81	15	17
ozarkensis	25	3	187.78	87.23	91.18	9.29	1.12	16	13
ozarkensis	25	4	188.13	106.62	86.85	7.62	1.54	14	14
ozarkensis	25	5	191.87	83.14	93.58	8.47	1.16	15	19
ozarkensis	25	6	162.98	73.33	67.69	6.84	0.94	14	15
ozarkensis	26	1	129.71	60.9	55.98	8.29	1.2	11	11
ozarkensis	26	2	175.51	71.86	88.43	7.7	1.29	13	14
ozarkensis	26	3	197.69	91.02	85	7.23	1.62	15	12
ozarkensis	26	4	199.33	93.49	72.02	6.23	1.51	15	16
ozarkensis	26	5	151.56	76.21	74.19	5.64	1.26	15	12
ozarkensis	27	1	158.54	72.71	61.65	6.13	1.19	16	15
ozarkensis	27	2	185.41	76.87	81.6	6.49	1.4	17	19
ozarkensis	27	3	184.57	68.31	78.76	5.82	1.4	18	18
ozarkensis	27	4	169.19	63.96	80.07	6.11	1.21	16	17
ozarkensis	27	5	136.92	46	70.72	6.09	0.9	17	17
ozarkensis	27	6	118.09	34.99	54.96	6.03	0.86	20	20
ozarkensis	28	1	130.26	66.37	65.28	4.7	1.03	13	13
ozarkensis	28	2	141.85	68.54	62.92	5.98	0.95	16	17
ozarkensis	28	3	170.57	70.48	77.92	7.53	1.12	15	14
ozarkensis	28	4	185.05	89.65	76.14	6.17	1.27	15	16
ozarkensis	28	5	202.75	87.81	96.86	6.3	1.37	15	16
ozarkensis	28	6	210.3	84	88.76	6.23	1.28	15	15
ozarkensis	29	1	129.24	61.77	65.74	6.86	2.02	10	12

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
ozarkensis	29	2	158.49	79.26	76.03	7.47	1.14	15	13
ozarkensis	29	3	183.61	79.52	81.12	8.72	1.08	14	17
ozarkensis	29	4	188.91	84.55	83.77	7.83	1.4	18	16
ozarkensis	29	5	189.44	89.79	77.44	8.23	1.35	13	15
ozarkensis	29	6	189.55	91.62	91.27	6.23	1.23	14	15
ozarkensis	29	7	131.92	56.86	52.48	4.58	1.02	12	12
ozarkensis	30	1	156.23	78.21	89.08	7.59	1.13	13	13
ozarkensis	30	2	168.18	73.7	92.63	7.53	1.09	13	13
ozarkensis	30	3	173.18	77.12	71.13	6.9	1.12	13	16
ozarkensis	30	4	191.37	81.97	98.05	7.65	1.09	14	14
ozarkensis	31	1	141.17	66.16	57.27	6.18	0.97	13	14
ozarkensis	31	2	133.86	55.46	58.67	8.29	1.05	15	14
ozarkensis	31	3	173.6	65.65	71.47	7.48	1.28	15	15
ozarkensis	31	4	198.17	79.14	58.11	8.66	1.57	14	13
ozarkensis	31	5	169.47	81.17	69.49	7.13	1.52	15	13
ozarkensis	31	6	172.8	83.84	62.55	7.4	1.33	13	13
ozarkensis	32	1	183.25	78.21	91.38	5.96	1.54	16	19
ozarkensis	32	2	193.66	85.21	70.14	6.77	1.58	16	15
ozarkensis	32	3	204.48	101.13	110.71	7.73	1.55	18	19
ozarkensis	32	4	221.98	104.22	125.29	8.05	1.51	22	19
ozarkensis	32	5	210.84	99.49	95.57	7.58	1.51	19	20
ozarkensis	32	6	166.43	70.41	76.52	6.42	1.41	19	18
ozarkensis	2018 - 10	1	194.42	68.11	91.68	7.12	1.55	20	18
ozarkensis	2018 - 10	2	184.92	66.88	98.96	7.17	1.15	17	19
ozarkensis	2018 - 10	3	162.59	59.4	84.33	9.61	0.96	16	18
ozarkensis	2018 - 10	5	163.65	56.43	75.14	5.01	1.28	18	19

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
ozarkensis	2018 - 10	6	161.79	52.65	79.21	4.32	0.98	18	20
ozarkensis	2018 - 11	1	149.01	64.12	61.95	5.76	1.19	12	12
ozarkensis	2018 - 11	3	162.31	70.25	85.89	5.13	1.76	17	17
ozarkensis	2018 - 11	4	149.81	64.87	71.75	5.71	1.1	17	17
ozarkensis	2018 - 12	1	152.74	60.61	71.46	7.67	1	12	11
ozarkensis	2018 - 12	2	156.78	64.66	67.89	6.48	0.91	13	13
ozarkensis	2018 - 12	5	181.94	73.54	87.58	5.34	1.25	14	13
ozarkensis	2018 - 13	2	157.1	60.26	65.48	6.04	1.2	14	14
ozarkensis	2019 - 13	4	182.87	72.81	85.07	4.78	1.24	15	17
ozarkensis	Hobbs SP	1	137.63	64.18	60.06	7.57	0.88	14	14
ozarkensis	Hobbs SP	2	117.83	47.1	53.61	8.57	0.91	14	14
ozarkensis	Hobbs SP	3	143.31	64	67.06	8.33	1.13	17	17
ozarkensis	Hobbs SP	4	152.17	71.48	73.85	7.66	1.26	16	15
ozarkensis	Hobbs SP	5	158.54	60.68	62.49	8.79	1.1	16	15
ozarkensis	Hobbs SP	6	176.66	79.93	82.73	9.54	1.19	19	19
ozarkensis	Hobbs SP	7	194.09	78.49	76.54	10.05	1.35	18	16
ozarkensis	Hobbs SP	8	163.79	67.47	69.41	7.83	1.06	17	17
ozarkensis	Withrow Springs 1/2	1	179.75	64.1	80.46	11.5	1.21	20	20
ozarkensis	Withrow Springs 1/2	2	182.79	68.97	93.73	10.75	1.42	17	15
ozarkensis	Withrow Springs 1/2	3	180.37	61.14	81.55	10.41	1.37	21	20
ozarkensis	Withrow Springs 1/2	4	176.47	61.32	94.74	10.36	1.22	20	17
ozarkensis	Withrow Springs 2/2	1	120.7	50.89	44.53	7.79	0.95	19	16
ozarkensis	Withrow Springs 2/2	2	155.53	56.58	77.82	6.73	0.85	16	19
ozarkensis	Withrow Springs 2/2	3	143.02	60.1	62.66	6.17	0.73	16	16
ozarkensis	Withrow Springs 2/2	4	162.15	64.6	72.3	10	0.96	16	15
ozarkensis	Withrow Springs 2/2	5	180.65	63.18	65.69	7.68	1.02	19	17

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
ozarkensis	Withrow Springs 2/2	6	182.92	70.19	68.32	7.21	1.1	16	15
ozarkensis	Withrow Springs 2/2	7	182.74	62.62	84.93	6.43	1.06	16	14
ozarkensis	Withrow Springs 2/2	8	163.16	63.12	64.03	5	0.76	15	15
ozarkensis	Withrow Springs 2/2	9	161.52	56.72	72.94	5.75	1.01	15	16
pumila	VPI-V-0024144	1	136.37	47.88	61.99	8.19	1.5	19	17
pumila	VPI-V-0024144	2	116.97	41.61	54.86	7.53	1.16	13	13
pumila	VPI-V-0024144	3	137.43	49.64	64.19	8.49	0.97	15	18
pumila	VPI-V-0024144	4	148.15	53.53	75.64	7.75	1.13	20	20
pumila	VPI-V-0024144	5	118.75	37.16	59.22	8.57	1.04	22	21
pumila	VPI-V-0024144	6	100.94	28.12	45.14	7.01	0.93	17	18
pumila	VPI-V-0024145	1	162.41	60.82	88.26	7.83	1.62	11	12
pumila	VPI-V-0024145	2	145.17	53.46	60.1	7.44	1.52	12	12
pumila	VPI-V-0024145	3	132.36	54.38	68.62	9.75	1.51	13	11
pumila	VPI-V-0024145	4	137.15	53.94	83.57	8.62	1.55	14	14
pumila	VPI-V-0024146	1	98.39	39.27	52.93	9.31	0.76	16	15
pumila	VPI-V-0024146	2	114.29	39.11	60.68	9.93	0.81	16	13
pumila	VPI-V-0024146	3	113.98	42.37	54.78	10.48	0.83	12	15
pumila	VPI-V-0024146	4	102.23	39.38	49.33	7.16	0.96	14	16
pumila	VPI-V-0024146	5	119.51	43.83	69.29	9.03	0.94	16	18
pumila	VPI-V-0024155	1	70.23	29.62	38.08	7.21	0.61	14	15
pumila	VPI-V-0024155	2	69.07	28.55	35.4	7.51	0.65	12	10
pumila	VPI-V-0024155	3	76.33	30.23	43.41	8.09	0.73	14	13
pumila	VPI-V-0024155	4	74.34	31.73	37.62	7.54	0.71	12	13
pumila	VPI-V-0024155	5	102.67	31.43	54.96	8.82	0.86	12	12
pumila	VPI-V-0024147	1	64.35	40.17	22.95	5.32	0.8	10	9
pumila	VPI-V-0024147	2	50.52	38.08	19.12	6.29	0.82	9	9

Appendix D. Continued.

C. pumila variety	Specimen No.	Leaf No.	Blade length (mm)	Blade width (mm)	Widest from tip (mm)	Petiole length (mm)	Petiole diameter (mm)	No. teeth L	No. teeth R
pumila	VPI-V-0024147	3	52.13	31.56	25.18	6.5	0.7	10	10
pumila	VPI-V-0024147	4	52.53	33.91	24.81	7.71	0.72	9	9
pumila	VPI-V-0024147	5	59.47	27.54	25.61	8.26	0.65	16	13
pumila	VPI-V-0024159	1	111.48	50.09	59.21	6.58	1.09	15	17
pumila	VPI-V-0024159	2	116.59	48.23	54.42	5.49	1.23	14	15
pumila	VPI-V-0024159	3	120.93	47.69	59.62	7.7	1.05	15	14
pumila	VPI-V-0024159	4	115.37	35.87	53.68	7.89	0.99	17	17
pumila	VPI-V-0024159	5	113.41	37.49	49.97	8.18	0.95	16	19
pumila	VPI-V-0024158	1	72.28	37.35	34.05	5.84	0.55	11	11
pumila	VPI-V-0024158	2	62.36	33.29	36.81	5.44	0.62	10	11
pumila	VPI-V-0024158	3	71.01	41.1	39.46	5.72	0.69	12	12
pumila	VPI-V-0024158	4	84.73	35.25	34.36	4.94	1.06	13	11
pumila	VPI-V-0024158	5	70.08	34.41	32.97	7.13	0.69	12	12
pumila	VPI-V-0024158	6	63.79	32.01	27.02	6.8	0.41	14	13
pumila	VPI-V-0024157	1	106.44	46.43	49.4	18.48	1.02	11	10
pumila	VPI-V-0024157	2	112.23	48.38	50.16	14.76	0.98	13	11
pumila	VPI-V-0024157	3	80.88	42.51	30.95	12.4	0.96	13	15
pumila	VPI-V-0024157	4	64.62	29.8	34.15	10.61	0.9	9	10
pumila	VPI-V-0024157	5	67.78	29.06	31.05	11.06	0.75	13	10
pumila	VPI-V-0024156	1	80.57	33.23	40.17	4.24	0.71	11	12
pumila	VPI-V-0024156	2	122.89	48.67	66.81	6.34	0.84	16	14
pumila	VPI-V-0024156	3	91.55	31.32	41.51	6.85	0.75	16	17

Appendix E. Raw shoot data.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
1	ozarkensis	6/1/2017	34.36881, -93.9575	1	D	4.99	2.5	Yes	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	2	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	3	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	4	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	5	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	6	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	7	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	8	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	9	A	0.99	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	10	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	11	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	12	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	13	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	14	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	15	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	16	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	17	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	18	A	1	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	19	A	2	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	20	A	2	2	No sign	Old on ground
1	ozarkensis	6/1/2017	34.36881, -93.9575	21	A	2	2	No sign	Old on ground
2	ozarkensis	6/1/2017	34.36876, -93.95745	1	A	4	2.5	Yes	None
2	ozarkensis	6/1/2017	34.36876, -93.95745	2	D	4	2.5	Yes	None
2	ozarkensis	6/1/2017	34.36876, -93.95745	3	A	2	1.5	Yes	None
2	ozarkensis	6/1/2017	34.36876, -93.95745	4	A	0.99	1	Yes	None
3	pumila	6/6/2017	33.14917, -94.02227	1	A	16.5	7	Yes	None
3	pumila	6/6/2017	33.14917, -94.02227	2	A	12	6.5	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
3	pumila	6/6/2017	33.14917, -94.02227	3	A	20	9	Yes	None
4	pumila	6/6/2017	33.19916, -94.03618	1	A	12.5	6	Yes	Developing
4	pumila	6/6/2017	33.19916, -94.03618	2	A	12	6	Yes	Developing
4	pumila	6/6/2017	33.19916, -94.03618	3	A	7.5	6	Yes	Developing
4	pumila	6/6/2017	33.19916, -94.03618	4	A	4.75	6	Yes	Developing
4	pumila	6/6/2017	33.19916, -94.03618	5	A	9.75	6	Yes	Developing
4	pumila	6/6/2017	33.19916, -94.03618	6	A	10	6	Yes	Developing
4	pumila	6/6/2017	33.19916, -94.03618	7	A	4	6	Yes	Developing
5	pumila	6/6/2017	33.64007, -93.00534	1	A	2.11	1	Yes	None
5	pumila	6/7/2017	33.64007, -93.00534	2	A	4	1.5	Yes	None
6	pumila	6/7/2017	33.64054, -93.00567	1	D	2	0.5	Yes	None
6	pumila	6/7/2017	33.64054, -93.00567	2	A	3.5	2	Yes	None
7	pumila	6/7/2017	33.64066, -93.00584	1	A	4.5	2.5	Yes	None
8	pumila	6/7/2017	33.64078, -93.00582	1	A	0.99	1	Yes	None
9	pumila	6/7/2017	33.64078, -93.00582	1	A	1.99	2	Yes	None
10	ozarkensis	6/7/2017	34.67985, -94.18316	1	A	2	2	Yes	None
10	ozarkensis	6/7/2017	34.67985, -94.18316	2	A	1	1	Yes	None
10	ozarkensis	6/7/2017	34.67985, -94.18316	3	A	0.99	1	Yes	None
10	ozarkensis	6/7/2017	34.67985, -94.18316	4	A	1.5	1	Yes	None
10	ozarkensis	6/7/2017	34.67985, -94.18316	5	A	0.99	0.99	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	1	D	11.6	3	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	2	D	17	5	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	3	A	0.99	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	4	A	0.99	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	5	A	0.99	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	6	A	0.99	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	7	A	0.99	2	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
11	ozarkensis	6/12/2017	34.68797, -93.9492	8	A	2	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	9	A	2	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	10	A	2	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	11	A	2	2	Yes	None
11	ozarkensis	6/12/2017	34.68797, -93.9492	12	A	2	2	Yes	None
12	ozarkensis	6/13/2017	34.39883, -93.76466	1	A	0.99	0.99	No sign	None
12	ozarkensis	6/13/2017	34.39883, -93.76466	2	A	0.99	0.99	No sign	None
13	ozarkensis	6/13/2017	34.86353, -93.03443	1	A	0.99	0.99	No sign	None
13	ozarkensis	6/13/2017	34.86353, -93.03443	2	A	0.99	0.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	1	D	7.11	4	Yes	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	2	D	8.3	3	Yes	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	3	D	6.2	4	Yes	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	4	A	2	1.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	5	A	2	1.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	6	A	2	1.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	7	A	2	1.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	8	A	2	1.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	9	A	3	2.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	10	A	3	2.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	11	A	3	2.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	12	A	4	2.99	No sign	None
14	ozarkensis	6/14/2017	34.86213, -92.80821	13	A	4	2.99	No sign	None
15	ozarkensis	6/14/2017	34.86212, -92.80812	1	D	4	2	Yes	None
15	ozarkensis	6/14/2017	34.86212, -92.80812	2	D	3.6	2.5	Yes	None
15	ozarkensis	6/14/2017	34.86212, -92.80812	3	A	1.99	1.99	No sign	None
15	ozarkensis	6/14/2017	34.86212, -92.80812	4	A	1.99	1.99	No sign	None
15	ozarkensis	6/14/2017	34.86212, -92.80812	5	A	1.99	1.99	No sign	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
15	ozarkensis	6/14/2017	34.86212, -92.80812	6	A	1.99	1.99	No sign	None
15	ozarkensis	6/14/2017	34.86212, -92.80812	7	A	1.99	1.99	No sign	None
17	ozarkensis	6/21/2017	36.10195, -92.18412	1	A	6	4	Yes	Developing
17	ozarkensis	6/21/2017	36.10195, -92.18412	2	A	6	4	Yes	Developing
17	ozarkensis	6/21/2017	36.10195, -92.18412	3	D	7	4.5	Yes	None
17	ozarkensis	6/21/2017	36.10195, -92.18412	4	A	0.99	0.99	No sign	None
17	ozarkensis	6/21/2017	36.10195, -92.18412	5	A	0.99	0.99	No sign	None
17	ozarkensis	6/21/2017	36.10195, -92.18412	6	A	0.99	0.99	No sign	None
17	ozarkensis	6/21/2017	36.10195, -92.18412	7	A	0.99	0.99	No sign	None
17	ozarkensis	6/21/2017	36.10195, -92.18412	8	A	0.99	0.99	No sign	None
17	ozarkensis	6/21/2017	36.10195, -92.18412	9	A	0.99	0.99	No sign	None
18	ozarkensis	6/22/2017	35.975, -92.22187	1	A	1.99	1.99	No sign	None
19	ozarkensis	6/22/2017	36.00602, -92.28023	1	A	1.99	1.99	No sign	None
20	ozarkensis	6/22/2017	36.02967, -92.43263	1	A	0.99	1.99	Yes	None
21	ozarkensis	6/27/2017	36.12615, -92.54935	1	A	1.5	1.5	No sign	None
21	ozarkensis	6/27/2017	36.12615, -92.54935	2	A	0.99	0.5	No sign	None
21	ozarkensis	6/27/2017	36.12615, -92.54935	3	A	0.99	0.5	No sign	None
22	ozarkensis	6/27/2017	36.13139, -92.54755	1	A	3	4	No sign	None
22	ozarkensis	6/27/2017	36.13139, -92.54755	2	A	0.99	0.99	No sign	None
22	ozarkensis	6/27/2017	36.13139, -92.54755	3	A	0.99	0.99	No sign	None
22	ozarkensis	6/27/2017	36.13139, -92.54755	4	D	0.99	0.99	Yes	None
23	ozarkensis	6/27/2017	36.13139, -92.54755	1	A	3.2	4	Yes	None
23	ozarkensis	6/27/2017	36.13139, -92.54755	2	A	0.99	0.5	No sign	None
24	ozarkensis	6/27/2017	36.03472, -92.63351	1	A	3.2	4	No sign	None
24	ozarkensis	6/27/2017	36.03472, -92.63351	2	A	2	1.5	No sign	None
24	ozarkensis	6/27/2017	36.03472, -92.63351	3	D	2.5	1	No sign	None
24	ozarkensis	6/27/2017	36.03472, -92.63351	4	A	0.99	1	No sign	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
25	ozarkensis	6/27/2017	36.07045, -92.57885	1	A	2.5	2	Yes	None
25	ozarkensis	6/27/2017	36.07045, -92.57885	2	D	2	1.5	Yes	None
25	ozarkensis	6/27/2017	36.07045, -92.57885	3	A	0.99	1	No sign	None
25	ozarkensis	6/27/2017	36.07045, -92.57885	4	A	0.99	0.99	No sign	None
25	ozarkensis	6/27/2017	36.07045, -92.57885	5	A	0.99	0.99	No sign	None
26	ozarkensis	6/27/2017	36.02918, -92.57656	1	A	1.99	1.5	No sign	None
26	ozarkensis	6/27/2017	36.02918, -92.57656	2	A	1.99	1.5	No sign	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	1	A	1.99	2	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	2	A	1.99	3	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	3	A	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	4	A	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	5	A	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	6	A	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	7	A	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	8	D	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	9	D	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	10	D	0.99	0.99	Yes	None
27	ozarkensis	6/28/2017	35.96621, -92.79984	11	D	0.99	0.99	Yes	None
28	ozarkensis	6/28/2017	35.98701, -92.7315	1	A	4.5	2.5	Yes	None
28	ozarkensis	6/28/2017	35.98701, -92.7315	2	D	2	1	Yes	None
28	ozarkensis	6/28/2017	35.98701, -92.7315	3	D	0.99	1	Yes	None
28	ozarkensis	6/28/2017	35.98701, -92.7315	4	A	0.99	1.5	Yes	None
28	ozarkensis	6/28/2017	35.98701, -92.7315	5	A	0.99	1.5	Yes	None
28	ozarkensis	6/28/2017	35.98701, -92.7315	6	A	0.99	1	Yes	None
29	ozarkensis	7/11/2017	35.96573, -93.38847	1	A	2.5	4	No sign	None
29	ozarkensis	7/11/2017	35.96573, -93.38847	2	A	1.75	3.5	Yes	None
29	ozarkensis	7/11/2017	35.96573, -93.38847	3	D	1.5	1.5	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
30	ozarkensis	7/11/2017	36.0507, -93.27435	1	A	6.75	3.5	No sign	None
30	ozarkensis	7/11/2017	36.0507, -93.27435	2	A	1.99	1.5	No sign	None
30	ozarkensis	7/11/2017	36.0507, -93.27435	3	D	1.99	0.99	Yes	None
30	ozarkensis	7/11/2017	36.0507, -93.27435	4	D	0.99	0.99	Yes	None
31	ozarkensis	7/11/2017	36.06023, -93.14145	1	D	7	4	Yes	None
31	ozarkensis	7/11/2017	36.06023, -93.14145	2	A	2	1.5	No sign	None
31	ozarkensis	7/11/2017	36.06023, -93.14145	3	A	0.99	0.99	No sign	None
31	ozarkensis	7/11/2017	36.06023, -93.14145	4	A	0.99	0.99	No sign	None
31	ozarkensis	7/11/2017	36.06023, -93.14145	5	A	0.99	0.99	No sign	None
32	ozarkensis	7/20/2017	36.33765, -94.09773	1	A	3	1.5	No sign	None
32	ozarkensis	7/20/2017	36.33765, -94.09773	2	A	0.99	1.5	No sign	None
2018 - 1	pumila	7/11/2018	33.44657, -93.36784	1	A	0.99	0.49	No sign	None
2018 - 1	pumila	7/11/2018	33.44657, -93.36784	2	A	0.99	0.49	No sign	None
2018 - 2	pumila	7/11/2018	33.44636, -93.3675	1	A	0.99	0.49	No sign	None
2018 - 2	pumila	7/11/2018	33.44636, -93.3675	2	A	0.99	0.49	No sign	None
2018 - 3	pumila	7/11/2018	33.44635, -93.3675	?	A	?	?	?	None
2018 - 4	pumila	7/11/2018	33.44622, -93.36737	1	D	3	3	Yes	None
2018 - 4	pumila	7/11/2018	33.44622, -93.36737	2	A	2.2	4	Yes	None
2018 - 4	pumila	7/11/2018	33.44622, -93.36737	3	A	1.4	2.5	Yes	None
2018 - 4	pumila	7/11/2018	33.44622, -93.36737	4	A	0.99	0.99	No sign	None
2018 - 4	pumila	7/11/2018	33.44622, -93.36737	5	A	0.99	0.99	No sign	None
2018 - 4	pumila	7/11/2018	33.44622, -93.36737	6	A	0.99	0.99	No sign	None
2018 - 5	pumila	7/11/2018	33.44625, -93.36747	1	A	0.99	0.99	No sign	None
2018 - 5	pumila	7/11/2018	33.44625, -93.36747	2	A	0.99	0.99	No sign	None
2018 - 5	pumila	7/11/2018	33.44625, -93.36747	3	A	0.99	0.99	No sign	None
2018 - 5	pumila	7/11/2018	33.44625, -93.36747	4	A	0.99	0.99	No sign	None
2018 - 5	pumila	7/11/2018	33.44625, -93.36747	5	A	0.99	0.99	No sign	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
2018 - 5	pumila	7/11/2018	33.44625, -93.36747	6	A	0.99	0.99	No sign	None
2018 - 6	pumila	7/11/2018	33.44622, -93.36751	1	D	3.6	2.5	Yes	None
2018 - 6	pumila	7/11/2018	33.44622, -93.36751	2	A	0.99	0.99	No sign	None
2018 - 6	pumila	7/11/2018	33.44622, -93.36751	3	A	0.99	0.99	No sign	None
2018 - 6	pumila	7/11/2018	33.44622, -93.36751	4	A	0.99	0.99	No sign	None
2018 - 7	pumila	7/11/2018	33.44625, -93.3675	1	A	0.99	1.25	No sign	None
2018 - 7	pumila	7/11/2018	33.44625, -93.3675	2	A	0.99	0.99	No sign	None
2018 - 7	pumila	7/11/2018	33.44625, -93.3675	3	A	0.99	0.99	No sign	None
2018 - 7	pumila	7/11/2018	33.44625, -93.3675	4	D	3.1	4.5	Yes	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	1	A	0.99	0.99	No sign	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	2	A	0.99	0.99	No sign	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	3	A	0.99	0.99	No sign	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	4	A	1.4	2.5	No sign	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	5	A	2.4	3	No sign	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	6	A	1.3	1.5	No sign	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	7	A	1	0.99	No sign	None
2018 - 8	pumila	7/11/2018	33.44607, -93.36742	8	A	1	0.99	No sign	None
2018 - 9	pumila	7/11/2018	33.65828, -93.16958	1	A	0.99	1	No sign	None
2018 - 9	pumila	7/11/2018	33.65828, -93.16958	2	A	0.99	1	No sign	None
2018 - 10	ozarkensis	7/12/2018	34.60616, -92.48378	1	D	1.2	2.5	No sign	None
2018 - 10	ozarkensis	7/12/2018	34.60616, -92.48378	2	A	0.99	1.5	No sign	None
2018 - 10	ozarkensis	7/12/2018	34.60616, -92.48378	3	A	0.99	1	No sign	None
2018 - 10	ozarkensis	7/12/2018	34.60616, -92.48378	4	A	0.99	0.99	No sign	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	1	D	4.3	4	Yes	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	2	D	7.2	4	Yes	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	3	D	3.5	2.5	Yes	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	4	D	1.9	2	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	5	D	4.1	4	Yes	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	6	D	2.7	4	Yes	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	7	D	1.2	1.5	Yes	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	8	D	1.4	3	Yes	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	9	A	0.99	1.5	No sign	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	10	A	0.99	0.99	No sign	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	11	A	0.99	0.99	No sign	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	12	A	0.99	0.99	No sign	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	13	A	0.99	0.99	No sign	None
2018 - 11	ozarkensis	7/12/2018	34.58644, -92.25388	14	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	1	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	2	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	3	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	4	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	5	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	6	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	7	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	8	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	9	A	0.99	0.99	No sign	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	10	D	0.99	1.49	Yes	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	11	D	0.99	1.49	Yes	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	12	D	0.99	1.49	Yes	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	13	D	0.99	1.49	Yes	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	14	D	0.99	1.49	Yes	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	15	D	0.99	1.49	Yes	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	16	D	0.99	1.49	Yes	None
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	17	D	5	1.5	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
2018 - 12	ozarkensis	7/12/2018	34.58658, -92.254	18	D	8.4	5	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	1	D	3.3	1.5	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	2	D	5.3	1	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	3	D	2.6	0.99	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	4	D	0.99	1.49	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	5	D	0.99	1.49	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	6	D	0.99	1.49	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	7	D	0.99	1.49	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	8	D	0.99	1.49	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	9	D	0.99	1.49	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	10	D	0.99	1.49	Yes	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	11	A	0.99	0.99	No sign	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	12	A	0.99	0.99	No sign	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	13	A	0.99	0.99	No sign	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	14	A	0.99	0.99	No sign	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	15	A	0.99	0.99	No sign	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	16	A	0.99	0.99	No sign	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	17	A	0.99	0.99	No sign	None
2018 - 13	ozarkensis	7/12/2018	34.58642, -92.25394	18	A	0.99	0.99	No sign	None
2018 - 14	pumila	7/17/2018	33.63437, -92.10161	1	A	0.99	0.99	No sign	None
2018 - 14	pumila	7/17/2018	33.63437, -92.10161	2	A	0.99	0.99	No sign	None
2018 - 14	pumila	7/17/2018	33.63437, -92.10161	3	A	0.99	0.99	No sign	None
2018 - 14	pumila	7/17/2018	33.63437, -92.10161	4	A	0.99	0.99	No sign	None
2018 - 14	pumila	7/17/2018	33.63437, -92.10161	5	A	0.99	1.5	No sign	None
2018 - 14	pumila	7/17/2018	33.63437, -92.10161	6	A	2.3	3	No sign	None
2018 - 14	pumila	7/17/2018	33.63437, -92.10161	7	D	4.1	0.99	Yes	None
2018 - 15	pumila	7/17/2018	33.63407, -92.10121	1	A	0.99	1.5	No sign	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
2018 - 15	pumila	7/17/2018	33.63407, -92.10121	2	A	0.99	2	No sign	None
2018 - 15	pumila	7/17/2018	33.63407, -92.10121	3	A	1	3	No sign	None
2018 - 15	pumila	7/17/2018	33.63407, -92.10121	4	A	1.2	4	No sign	None
2018 - 15	pumila	7/17/2018	33.63407, -92.10121	5	A	1.7	4	No sign	None
2018 - 16	pumila	7/17/2018	33.63528, -92.1007	1	A	0.99	0.99	No sign	None
2018 - 16	pumila	7/17/2018	33.63528, -92.1007	2	A	0.99	0.99	No sign	None
2018 - 16	pumila	7/17/2018	33.63528, -92.1007	3	A	0.99	0.99	No sign	None
2018 - 16	pumila	7/17/2018	33.63528, -92.1007	4	D	6.4	1	Yes	None
2018 - 17	pumila	7/18/2018	33.27421, -92.60142	1	A	2	1.5	No sign	None
2018 - 17	pumila	7/18/2018	33.27421, -92.60142	2	A	2	1.5	No sign	None
2018 - 17	pumila	7/18/2018	33.27421, -92.60142	3	A	0.99	1	No sign	None
2018 - 17	pumila	7/18/2018	33.27421, -92.60142	4	A	0.99	0.99	No sign	None
DBNA 1	ozarkensis	6/21/2017	36.00521, -92.04791	1	A	3.5	3	Yes	None
DBNA 1	ozarkensis	6/21/2017	36.00521, -92.04791	2	A	3.2	2.5	Yes	None
DBNA 1	ozarkensis	6/21/2017	36.00521, -92.04791	3	A	3	2.5	Yes	None
DBNA 1	ozarkensis	6/21/2017	36.00521, -92.04791	4	D	0.99	1.5	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	1	A	7	4	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	2	A	3.5	4	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	3	A	3	2.5	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	4	D	5.2	4.5	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	5	A	0.99	1.5	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	6	A	0.99	1.5	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	7	A	0.99	0.99	Yes	None
DBNA 2	ozarkensis	6/21/2017	36.00514, -92.04797	8	A	0.99	0.99	Yes	None
HSP 1	ozarkensis	10/17/2016	36.29132, -93.93077	1	D	5.75	3	Yes	None
HSP 1	ozarkensis	10/17/2016	36.29132, -93.93077	2	A	4	3	Yes	None
HSP 1	ozarkensis	10/17/2016	36.29132, -93.93077	3	A	0.99	1.5	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
HSP 1	ozarkensis	10/17/2016	36.29132, -93.93077	4	A	0.99	1	Yes	None
HSP 1	ozarkensis	10/17/2016	36.29132, -93.93077	5	A	1	0.99	Yes	None
HSP 2	ozarkensis	10/17/2016	36.29137, -93.93081	1	A	1	1.5	Yes	None
HSP 2	ozarkensis	10/17/2016	36.29137, -93.93081	2	A	0.99	1	Yes	None
HSP 3	ozarkensis	10/17/2016	36.29252, -93.93115	1	A	3.2	4	Yes	None
HSP 3	ozarkensis	10/17/2016	36.29252, -93.93115	2	A	4	4.5	Yes	None
HSP 3	ozarkensis	10/17/2016	36.29252, -93.93115	3	A	2.5	3	Yes	None
HSP 4	ozarkensis	10/17/2016	36.29256, -93.93119	1	A	3.3	3	Yes	None
HSP 4	ozarkensis	10/17/2016	36.29256, -93.93119	2	A	3.2	3	No sign	None
HSP 5	ozarkensis	10/17/2016	36.29309, -93.93098	1	A	6.11	5	Yes	None
HSP 5	ozarkensis	10/17/2016	36.29309, -93.93098	2	A	0.99	1.5	Yes	None
HSP 5	ozarkensis	10/17/2016	36.29309, -93.93098	3	D	7	5	Yes	None
HSP 5	ozarkensis	10/17/2016	36.29309, -93.93098	4	D	4.75	6	Yes	None
HSP 5	ozarkensis	10/17/2016	36.29309, -93.93098	5	D	4.11	3	Yes	None
HSP 5	ozarkensis	10/17/2016	36.29309, -93.93098	6	D	0.99	1.99	Yes	None
HSP 6	ozarkensis	10/17/2016	36.29374, -93.93115	1	A	2.6	2.5	Yes	None
HSP 6	ozarkensis	10/17/2016	36.29374, -93.93115	2	D	6	2	Yes	None
HSP 7	ozarkensis	10/17/2016	36.29407, -93.93095	1	A	0.99	1	No sign	None
HSP 8	ozarkensis	10/17/2016	36.29534, -93.93089	1	A	0.99	0.99	No sign	None
HSP 8	ozarkensis	10/17/2016	36.29534, -93.93089	2	D	6.3	6	Yes	None
HSP 8	ozarkensis	10/17/2016	36.29534, -93.93089	3	D	4.8	5	Yes	None
HSP 8	ozarkensis	10/17/2016	36.29534, -93.93089	4	D	4.5	5	Yes	None
HSP 8	ozarkensis	10/17/2016	36.29534, -93.93089	5	D	4.3	4	Yes	None
HSP 9	ozarkensis	10/17/2016	36.29694, -93.9314	1	A	0.99	1	No sign	None
HSP 10	ozarkensis	10/17/2016	36.2984, -93.93305	1	A	3.4	4.5	No sign	None
HSP 10	ozarkensis	10/17/2016	36.2984, -93.93305	2	A	3.11	1	No sign	None
HSP 10	ozarkensis	10/17/2016	36.2984, -93.93305	3	D	0.99	1.5	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
HSP 11	ozarkensis	10/17/2016	36.29851, -93.9335	1	A	0.99	0.99	No sign	None
HSP 11	ozarkensis	10/17/2016	36.29851, -93.9335	2	A	0.99	0.99	Yes	None
HSP 12	ozarkensis	10/17/2016	36.29852, -93.93384	1	A	4.5	3	Yes	None
HSP 13	ozarkensis	10/17/2016	36.2985, -93.93382	1	A	5.11	4	Yes	None
HSP 14	ozarkensis	10/17/2016	36.29849, -93.93377	1	A	6	3.99	Yes	None
HSP 14	ozarkensis	10/17/2016	36.29849, -93.93377	2	D	15	6	Yes	None
HSP 15	ozarkensis	10/17/2016	36.29845, -93.93379	1	A	2	1.75	No sign	None
HSP 15	ozarkensis	10/17/2016	36.29845, -93.93379	2	D	2	1	Yes	None
HSP 16	ozarkensis	10/17/2016	36.29847, -93.93384	1	A	2	2	No sign	None
HSP 16	ozarkensis	10/17/2016	36.29847, -93.93384	2	D	3.5	2	Yes	None
HSP 17	ozarkensis	10/17/2016	36.29903, -93.93467	1	A	2.5	1.75	No sign	None
HSP 18	ozarkensis	10/17/2016	36.3018, -93.93674	1	A	5.8	6	Yes	None
WSSP 1	ozarkensis	10/7/2016	36.159333, -93.72905	1	A	13.4	7	Yes	None
WSSP 1	ozarkensis	10/7/2016	36.159333, -93.72905	2	A	5	5	No sign	None
WSSP 1	ozarkensis	10/7/2016	36.159333, -93.72905	3	A	3	4	No sign	None
WSSP 2	ozarkensis	10/7/2016	36.1591, -93.72885	1	A	2.6	3.5	No sign	None
WSSP 2	ozarkensis	10/7/2016	36.1591, -93.72885	2	A	2.4	2	Yes	None
WSSP 3	ozarkensis	10/7/2016	36.15893, -93.72897	1	A	0.99	1.25	Yes	None
WSSP 3	ozarkensis	10/7/2016	36.15893, -93.72897	2	A	0.99	0.5	Yes	None
WSSP 3	ozarkensis	10/7/2016	36.15893, -93.72897	3	A	0.99	0.3	Yes	None
WSSP 4	ozarkensis	10/7/2016	36.15893, -93.729	1	A	0.99	1.75	No sign	None
WSSP 5	ozarkensis	10/7/2016	36.15887, -93.72903	1	A	0.99	1	No sign	None
WSSP 5	ozarkensis	10/7/2016	36.15887, -93.72903	2	A	0.99	0.5	No sign	None
WSSP 5	ozarkensis	10/7/2016	36.15887, -93.72903	3	D	1.2	2	Yes	None
WSSP 6	ozarkensis	10/7/2016	36.15888, -93.72902	1	A	1	2.25	Yes	None
WSSP 6	ozarkensis	10/7/2016	36.15888, -93.72902	2	A	0.25	0.25	Yes	None
WSSP 6	ozarkensis	10/7/2016	36.15888, -93.72902	3	D	4	4	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
WSSP 7	ozarkensis	10/7/2016	36.15887, -93.72903	1	D	3	2	Yes	None
WSSP 7	ozarkensis	10/7/2016	36.15887, -93.72903	2	A	0.5	1.5	Yes	None
WSSP 7	ozarkensis	10/7/2016	36.15887, -93.72903	3	A	0.25	0.25	Yes	None
WSSP 8	ozarkensis	10/7/2016	36.15865, -93.72923	1	A	4.5	4	Yes	None
WSSP 8	ozarkensis	10/7/2016	36.15865, -93.72923	2	A	0.99	1	No sign	None
WSSP 8	ozarkensis	10/7/2016	36.15865, -93.72923	3	A	0.99	1.25	No sign	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	1	A	0.99	1	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	2	A	0.99	1	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	3	A	0.99	0.25	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	4	D	4.25	4	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	5	D	4	4	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	6	D	2.5	2	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	7	D	0.99	1	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	8	D	0.99	1	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	9	D	0.99	1	Yes	None
WSSP 9	ozarkensis	10/7/2016	36.15865, -93.72908	10	D	0.99	1	Yes	None
WSSP 10	ozarkensis	10/7/2016	36.15845, -93.72932	1	A	3.5	5	No sign	None
WSSP 10	ozarkensis	10/7/2016	36.15845, -93.72932	2	A	3.5	3.5	No sign	None
WSSP 10	ozarkensis	10/7/2016	36.15845, -93.72932	3	A	1.5	1.5	No sign	None
WSSP 10	ozarkensis	10/7/2016	36.15845, -93.72932	4	A	1	1	No sign	None
WSSP 10	ozarkensis	10/7/2016	36.15845, -93.72932	5	D	4	3	Yes	None
WSSP 10	ozarkensis	10/7/2016	36.15845, -93.72932	6	D	1	2	Yes	None
WSSP 11	ozarkensis	10/7/2016	36.15845, -93.72937	1	A	1.5	2	Yes	None
WSSP 12	ozarkensis	10/7/2016	36.15845, -93.72937	1	A	7.75	4	Yes	None
WSSP 12	ozarkensis	10/7/2016	36.15845, -93.72937	2	D	1.25	4	Yes	None
WSSP 13	ozarkensis	10/7/2016	36.1584, -93.7294	1	A	0.99	1.5	Yes	None
WSSP 13	ozarkensis	10/7/2016	36.1584, -93.7294	2	A	0.99	1	Yes	None

Appendix E. Continued.

Clone No.	C. pumila variety	Date	Coordinates	Stem No.	Dead/alive	DBH (mm)	Height (m)	Blight?	Fruit?
WSSP 14	ozarkensis	10/7/2016	36.1583, -93.7294	1	A	8.25	6	No sign	None
WSSP 14	ozarkensis	10/7/2016	36.1583, -93.72937	2	A	1	2	No sign	None
WSSP 14	ozarkensis	10/7/2016	36.1583, -93.72937	3	D	6.5	4	Yes	None
WSSP 14	ozarkensis	10/7/2016	36.1583, -93.72937	4	D	7	5	Yes	None
WSSP 15	ozarkensis	10/7/2016	36.15827, -93.72927	1	A	*	2	*	None
WSSP 15	ozarkensis	10/7/2016	36.15827, -93.72927	2	A	*	2	*	None
WSSP 16	ozarkensis	10/7/2016	36.15802, -93.72922	1	A	*	2	*	None
WSSP 16	ozarkensis	10/7/2016	36.15802, -93.72922	2	A	*	2	*	None
WSSP 16	ozarkensis	10/7/2016	36.15802, -93.72922	3	A	*	2	*	None
WSSP 17	ozarkensis	10/7/2016	36.15802, -93.72913	1	A	12.8	6	*	None
WSSP 17	ozarkensis	10/7/2016	36.15802, -93.72913	2	A	1	1	*	None
WSSP 17	ozarkensis	10/7/2016	36.15802, -93.72913	3	D	4	2.5	Yes	None
WSSP 18	ozarkensis	10/7/2016	36.15797, -93.72928	1	A	1	1	*	None
WSSP 18	ozarkensis	10/7/2016	36.15797, -93.72928	2	A	1	1	*	None
WSSP 18	ozarkensis	10/7/2016	36.15797, -93.72928	3	D	7.5	5	Yes	None

Appendix F. Woody plant taxa observed in association with each variety. n = number of sites where association was observed.

	C. pumila var. ozarkensis	*C. pumila var. pumila*
Acer rubrum	27	1
Acer saccharinum	3	0
Acer saccharum	1	0
Aesculus spp.	1	0
Alnus serrulate	3	0
Amelanchier arborea	1	0
Aralia spinosa	2	0
Asimina trilobal	5	1
Carpinus caroliniana	1	12
Cercis canadensis	2	0
Cornus florida	28	3
Castanea pumila var. ozarkensis	26	0
Castanea pumila var. pumila	0	8
Carya aquatica	0	1
Carya cordiformis	0	8
Carya glabra	8	1
Carya tomentosa	38	8
Fagus grandifolia	2	0
Frangula caroliniana	1	0
Fraxinus caroliniana	0	1
Fraxinus pennsylvanica	2	0
Gleditsia triacanthos	0	0
Hamamelis virginiana	2	12
Ilex opaca	0	17
Juglans nigra	1	0
Juniperus virginiana	14	2
Lonicera japonica	1	0
Liriodendron styraciflua	10	9
Morella cerifera	0	1

Appendix F. Continued

	C. pumila var. ozarkensis	*C. pumila var. pumila*
Morus rubra	4	0
Nyssa sylvatica var. sylvatica	23	14
Ostrya virginiana	0	4
Prunus serotina	1	0
Parthenocissus quinquefolia	4	0
Pinus echinata	25	6
Pinus taeda	0	10
Quercus alba	40	14
Quercus arkansana	0	6
Quercus falcata	3	2
Quercus incana	0	1
Quercus margaretta	0	1
Quercus marilandica	3	0
Quercus meuhlenbergii	5	0
Quercus nigra	1	12
Quercus phellos	1	1
Quercus rubra	18	3
Quercus stellata	7	0
Quercus velutina	21	6
Rhus copallinum	2	0
Rhus glabra	0	1
Robinia pseudoacacia	1	0
Sassafras albidum	12	3
Smilax spp.	4	0
Toxicodendron radicans	9	11
Ulmus alata	2	8
Ulmus rubra	2	0
Vitis spp.	8	13