ELMWOOD STOCK FARM TREE REPORT

PREPARED BY THE UK URBAN FOREST INITIATIVE

N . Williamson, M.S., L . Rieske-Kinney, Ph. D, M. Arthur, Ph. D, C. Sass, Ph.D, and B. Kist.

2019 INVENTORY TEAM

Nic Williamson, M.S.
Mary Arthur, Ph.D
Lynne Rieske-Kinney, Ph.D
Brian Kist
Joshua DeHaan
Brandon Foley
Angela Sanchez
Seth Mullins

THE URBAN FOREST INITIATIVE

The Urban Forest Initiative (UFI) at the University of Kentucky aims to improve understanding of the role of trees in and near human communities with a goal of increasing awareness of the importance of trees (i.e. green infrastructure) in towns and cities. Prior to and throughout this project, UFI has focused tree inventory work on street trees in neighborhoods and cities around the state, linking those trees to the ecosystem benefits they confer while addressing areas for improvement in the diversity and distribution of trees among species and size class. This project at Elmwood Stock Farm is our first foray into quantifying and describing the benefits of trees at the urban-rural interface.

Report issued December 2022

URBAN FOREST INITIATIVE

Email: ufi.uky.edu
Web: ufi.ca.uky.edu

UFI summer interns near a very large (44 inch DBH) bur oak tree adjacent to one of Elmwood's barns.


Photo obtained from Pexels.com

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Cover photo: Large bur oak tree located on Elmwood Stock Farm property.

EXECUTIVE SUMMARY

Trees and forest patches located at the urban-rural interface are some of the most valuable trees for conserving ecosystem services, yet are rarely the focus of ecological or forestry studies. This report is the product of a joint venture to inventory the trees on the Elmwood Stock Farm near Georgetown, KY. The Urban Forest Initiative (UFI) embarked on this project with the aim of quantifying species composition, size distributions and health of the tree canopy, estimating a suite of ecosystem benefits, and developing recommendations and considerations for future management. The project highlights the importance of trees at the urban-rural interface, and stimulates new thinking about how to highlight the trees in rural communities. Herein we interpret the findings of this tree survey within the context of Elmwood Stock Farm and the broader Kentucky Inner Bluegrass Region. We anticipate that both the approach and findings of the Elmwood tree survey will be relevant for considering interplay of farm trees with the variety of landscape usages common in production agriculture.

The University of Kentucky Urban Forest Initiative (UFI) Core Team measured a selected sample of trees at Elmwood Stock Farm in Summer 2019 with the following project goals:

+ To pilot efforts to learn the structure and distribution of farm trees at the urban-rural interface in our region

+ To establish protocols that align with the varied land uses within a single farm

+ To provide recommendations for creating a more intentional suite of tree species on the farm aimed at enhancing the function and sustainability of Elmwood trees

This report is a synthesis of UFI's inventory and analysis and includes the following information about Elmwood's trees based on a sub-sample of the key land-use areas:

+ species composition and diversity

+ size-class structure

+ ecosystem services

BACKGROUND

ABOUT ELMWOOD STOCK FARM TREES

Elmwood Stock Farm is a 6th-generation family-owned farm known for its sustainable farming practices located on 550 acres in Scott County, Kentucky. Like many farms in central Kentucky, trees dot the landscape in various contexts, providing refuge for livestock on hot summer days, slowing wind gusts common in Ohio River Valley weather patterns, and generally making the farm a more livable and workable place for humans and farm animals alike. Additionally, farm trees provide the same sorts of benefits (ecosystem services) that trees provide anywhere on the landscape including mitigating stormwater, sequestering and storing carbon, reducing air pollution and soil erosion, and providing critical habitat for pollinators. Despite all this, sustenance of the Elmwood Stock Farm hinges upon their Community Supported Agriculture program and related farm operations. Consideration and management of the farm's trees are often and understandably relegated to the "slow" season or on an "as-needed" basis. Elmwood's farm trees are uniquely tied to current and past land use history on the farm, all of which highlight management implications for the farm's future tree canopy.

FACTS ABOUT ELMWOOD STOCK FARM TREES

Pasture

+ Abundance of mature, historically and ecologically significant trees (blue ash, bur oak, chinquapin oak)

+ Pasture tree canopy has been decreasing for some time and some species (e.g. blue ash) are declining in health

Farm Roads

+ Differences in species composition and size distribution between roads and road sections

+ Hackberry and black cherry on south section of eastern road tied to evolution of this farm road over 60 years; western road contains intentional legacy plantings including numerous large catalpa trees

Fencerows

+ Dominated by hackberry, one of the most common volunteer species in our region

+ Future canopy likely to remain hackberry without selective measures

Homesteads

+ Highest tree species diversity on the farm

+ Diversity is the result of a sustained effort to introduce desirable species that bring aesthetics (e.g., fall color) and function (e.g. year-round shade) to human dwellings, along with volunteer trees and a small number of ecologically significant trees.

BACKGROUND

ELMWOOD'S TOP 10 MOST IMPORTANT TREE SPECIES AND THEIR LOCATIONS

Table 1: Note that our analysis is based on a sub-sample of Elmwood's trees, described in detail in the "Scope and Approach" section.

			Location of species by farm land use			
Botanical Name	**Common Name**	**Number of Trees**	**Pasture**	**Farm Roads**	**Fence-rows**	**Home-steads**
Celtis occidentalis	hackberry	230	X	X	X	X
Prunus serotina	black cherry	113	X	X	X	X
Fraxinus quadrangulata	blue ash	26	X	X	–	–
Juglans nigra	black walnut	55	X	X	X	X
Quercus macrocarpa	bur oak	19	X	X	X	X
Catalpa speciosa	catalpa	36	–	X	–	–
Quercus muehlenbergii	chinkapin oak	8	X	–	–	–
Robinia pseudoacacia	black locust	23	–	X	X	X
Acer saccharinum	silver maple	13	–	X	–	X
Platanus occidentalis	sycamore	7	–	X	–	X
	Other Species	98	–	–	–	–
	Total Trees Measured	628	–	–	–	–

SCOPE AND APPROACH

It was immediately evident from our initial conversations with John, Ann and Mac that trees on the farm serve a multitude of purposes, and that those differences in purpose are tied to differences in land use within the property. Measuring and mapping every tree on the farm was impractical, so we formulated an approach to sub-sample trees within four different land use categories specific to Elmwood (and likely other regional diversified farms): trees found in pastures, along roads, along fencerows and around homesteads.

Figure 1: Trees inventoried (each dot is an individual tree) at Elmwood Stock Farm that were measured. Tree (dot) colors show land use types we used in our analysis: pasture (purple), farm roads (red), fencerows (yellow), and homesteads (blue).

In fields and pastures, where livestock and trees interact, we were limited to one large field (Figure 1; purple dots). Homestead areas were selected as those containing built structures (e.g., houses or barns) with surrounding trees (Fig. 1; blue dots). To characterize fencerow trees we selected 3 fenceline segments, together covering about 0.5 miles of fencerows (Fig. 1; green dots). On farm roads, sampling was conducted along 1.25 miles of roadway (Fig. 1; red dots). We chose the areas for sampling based on discussions with farm management, coupled with landscape nuances that became apparent after site visits. For example, some road sections were heavily tree-lined (generally the ones we sampled) while others were virtually tree-less.

SCOPE AND APPROACH

The four landscape distinctions separated the trees and their functions and allowed us to consider the ways in which land use shapes tree species composition and tree size across a spectrum of sites on the farm. Discussions with John, Ann and Mac and referencing historic USGS aerial photos provided historical and landscape context that otherwise might not have been apparent to a team of visiting academics and urban foresters whose prior tree inventorying experience focused on urban locations, driving home the importance of conversing about site usage and context with Elmwood's farm managers.

In areas selected for sampling, we measured trees larger than 1-inch diameter at breast height (DBH; 4.5 feet above ground surface). For each measured tree we recorded species, DBH, condition of wood, condition of leaves, and percent canopy deadwood (Cowett and Bassuk 2012). Tools for data collection included DBH tapes and a formatted data collection feature service in Arc Collector, an Environmental Systems Research Institute (ESRI) product. Collected tree data were analyzed using ESRI's online and desktop GIS applications as well as Microsoft Excel®. Data collection was completed by UFI staff and four summer UK student interns, and data analysis and development of this report was completed by the UFI team.

We synthesized the information on tree species and size to present and highlight the differences among the land use types, which have implications for management. On the next page are some key terms and descriptions used frequently in the Elmwood tree analysis report.

Photo obtained from kentuckytourism.com

SCOPE AND APPROACH

Diameter-at-breast-height (DBH), defined as trunk diameter at 4.5 feet from the ground, is a measurement of tree size. Tree age, site, soil, land use history, and many other factors directly affect the growth, and therefore size, of any tree.

Relative abundance (%), defined as the number (count) of individuals of a given species (or genus, or family) out of a total number of trees (totals being all trees within a given land use type, or all trees measured on the farm) throughout our analysis.

Basal area, calculated from DBH, measures the cross-sectional area of a tree at breast height and provides a measure of the trunk area that a single tree occupies, which is strongly correlated with the canopy size. Basal area was calculated using the equation, where r = radius (1/2 of tree DBH): Basal area = $\pi * r^2$

Relative basal area was calculated by summing the basal area of each individual tree of each species, and then dividing the species' total basal area by the total basal area of all trees in the sample, either within a given land use site or total trees on the farm, as noted with each figure or table.

Importance value by tree species is an average of the relative basal area and relative abundance of each tree species. Here when we speak of tree species importance values we are reporting the extent to which a tree species "occupies" a given land area, calculated from the proportion of individual trees (relative abundance) and proportion of tree basal area (relative basal area) of each tree species relative to the total.

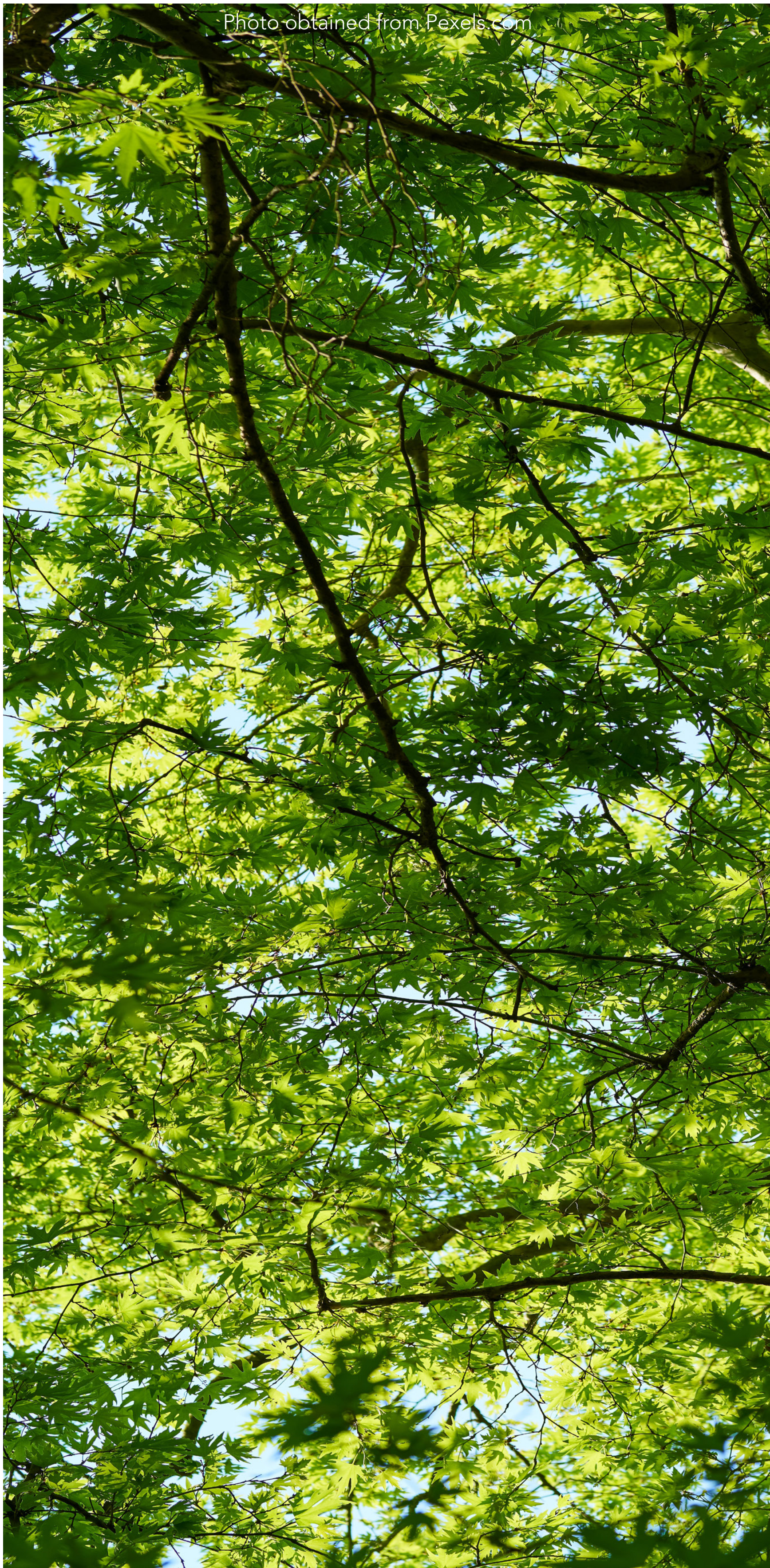
Photo obtained from Pexels.com

SCOPE AND APPROACH

We also reference the 30-20-10 rule for tree diversity (Santamour 1990), which suggests aiming for no more than 30% of individual trees of one family, 20% of one genus, and 10% of one tree species in a given tree population in an urban setting. The multitude of considerations for evalutating tree species diversity are under continuous study and some contention exists as to the value of the 30-20-10 rule applied strictly. At its essence, we recognize this rule as a useful tool for examining the diversity of tree species on a site, and have applied it to the rural tree canopy at Elmwood.

In addition, we depart somewhat from the tradition of using Santamour's 30-20-10 rule within the context of species (and genus and family) relative abundance. In this analysis we have piloted the addition of relative basal area and importance value for application of the 30-20-10 rule. Importance value is what we are using as a basis for comparison with Santamour's 30-20-10. This approach tends to rank species with larger individual trees higher and species with smaller individuals lower than using abundance alone, providing a more accurate representation of the presence of each particular species on site. It is worth noting that this approach assumes that the size and abundance of trees is a more important consideration than either factored separately, which makes good sense from a great many ecosystem benefit perspectives. There may be nuances (e.g. trying to shape tree canopy to attract particular wildlife) where the preference for larger trees is less predominant.

A tree population size guideline for urban forests of 40% of all stems made up of small trees (0-8 inch DBH), 30% small to medium trees (8-16 inch DBH), 20% medium to large trees (16-24 inch DBH), and 10% large trees (24 inches and above DBH) (Richards 1983) is referenced to discuss the size structure of Elmwood's tree collection. A spread of tree sizes ensures there are enough young trees to replenish the farm forest but also recognizes the importance in promoting the maturation of trees on site. This guideline is also suggested as a tool to query the data regarding whether or not the tree canopy is lacking in size diversity, but again, should be used in the context of management goals and the idiosyncrasies of the different land uses.

It is worth mentioning that the above approach to tree size-class analysis ignores the fact that some tree species (e.g., crabapple, hawthorn) are smaller by nature. In sites where smaller growing species are abundant this can skew the size structure toward smaller size classes. We discovered only a few small tree species growing trees in our Elmwood tree survey, and their presence was mostly around homesteads. In more urbanized environments these smaller growing species are common, and in many instances their selection is ideal where soil volume is limited. These smaller species may also be more prevalent due to them being readily available at commercial garden centers and prefered at tree giveaways, particularly by utility companies (personal observation). Overall this seems worth noting as a reminder that this consideration of size-class could suggest that tree size is of the highest importance, thereby ignoring a more nuanced interpretation of the cast of species present and their contributions to diversity and ecosystem services.

SCOPE AND APPROACH

As mentioned, our approach to sampling trees at Elmwood was based on an initial classification of four different land use categories on the farm: pastures, farm roads, fencerows and homesteads. The tree findings in each of the 4 sections highlighted key findings, which are expanded upon below in the corresponding sections.

Table 2 provides a quick look at the number of trees measured in each of the land use types and the number of tree species identified therein.

	Trees Measured	Number of Species
Homesteads	230	32
Farm Roads	251	17
Pastures	39	6
Fencerows	108	7

Photo obtained from Pexels.com

ELMWOOD TREES BY LAND USE: PASTURES

KEY FINDINGS:

+ 39 trees measured, 6 species represented

+ Abundance of mature, historically and ecologically significant tree species (blue ash, bur oak, chinquapin oak)

+ Pasture tree canopy has been decreasing for some time and some tree species (e.g. blue ash) are declining in health

Photo obtained from Pexels.com

ELMWOOD TREES BY LAND USE: PASTURES

Diversity: Species and Size

Table 3: Elmwood pasture tree species, along with their associated relative abundance, relative basal area, and relative importance value. All pasture trees measured (n=39) are included here, sorted by relative importance value.

Botanical name	Common name	# of trees measured	Species Relative Abundance (%)	Relative Basal Area (% of site total)	Relative Importance Value (%)
Fraxinus quadrangulata	blue ash	19	48.7%	44.6%	46.7%
Quercus muehlenbergii	chinquapin oak	8	20.5%	29.6%	25.1%
Quercus macrocarpa	bur oak	5	12.8%	18.4%	15.6%
Juglans nigra	black walnut	5	12.8%	4.3%	8.5%
Fraxinus americana	white ash	1	2.6%	2.6%	2.6%
Gymnocladus dioicus	Kentucky coffee tree	1	2.6%	0.5%	0.5%
Total		39	100.0%	100.0%	100.0%

Comparing the importance values of Elmwood's pasture trees to Santamour's 30-20-10 rule, Table 3 shows three species that surpass the recommended 10% threshold for any single species: blue ash (46.7%), chinquapin oak (25.1%), bur oak (15.6%). A key reason for this rule is that pests and diseases are regularly host-specific to specific species (or genus or family) and was also unfortunately on display in the invasive emerald ash borer's damage of the pasture's blue ash trees. The 20% threshold for the genus taxonomic level was also surpassed by ash (49.3%), as well as oak (40.7%). Following suit, the 30% threshold for the family taxonomic level was surpassed by Oleaceae (ash) (49.3%), as well as Fagaceae (oak) (40.7%).

ELMWOOD TREES BY LAND USE: PASTURES

Diversity: Species and Size

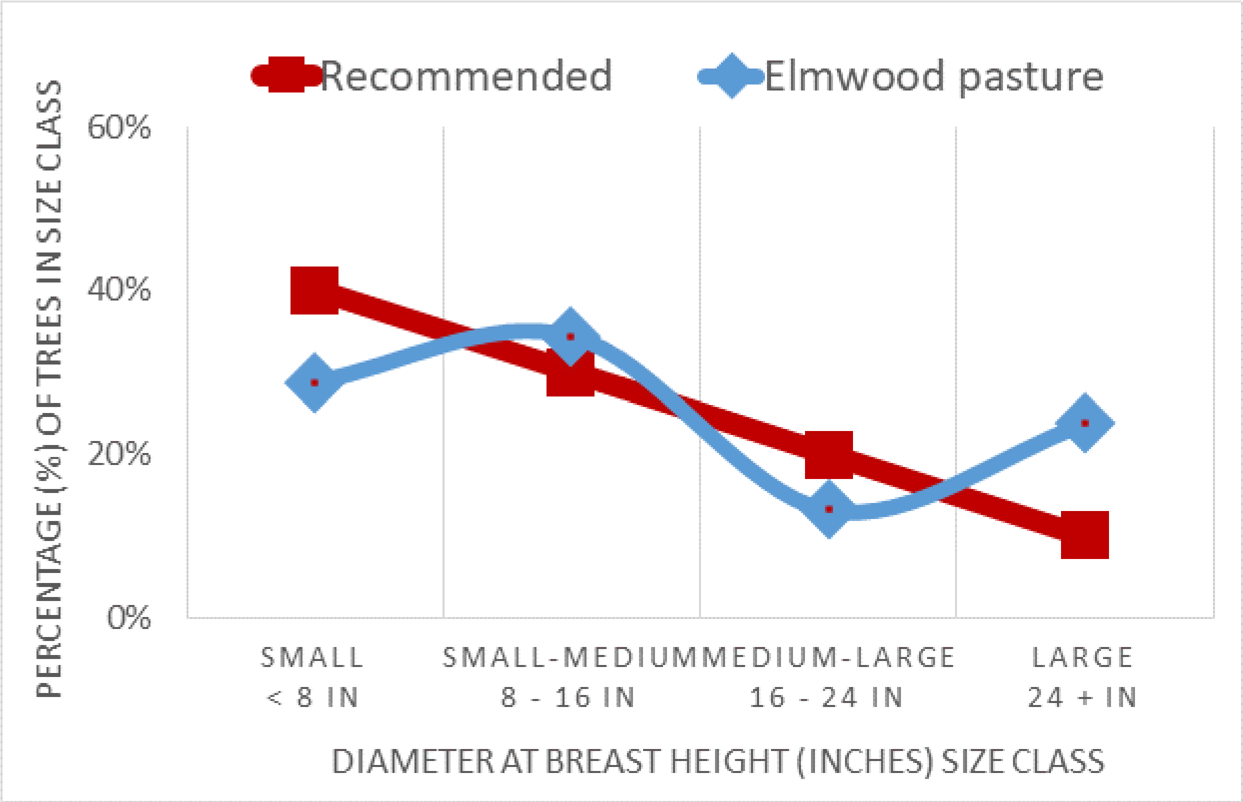

Figure 2: Size class distribution of Elmwood pasture trees (blue line) compared to the recommended distribution (red line) proposed by Richards (1983).

The tree size class distribution of the trees measured on a single pasture at Elmwood Stock Farm (Figure 2) shows the high number of large (24+ inch class) mature trees. We measured more than twice the recommended proportion in this size class, 23.7% compared to the recommended 10% (Richards 1983). Moving down in size classes (to the left on the graph), we see that 13.2% of pasture trees were medium-large (16-24 inch DBH), below the recommended 20%, and 34.3% of trees were small-medium (8-16 inch DBH), above the 30% target. Small trees (<8 inch DBH) made up 28.8% of pasture trees, well below Richards' (1983) recommended 40% for that size class. Below we discuss diversity and size considerations at this Elmwood site.

ELMWOOD TREES BY LAND USE: PASTURES

Management Considerations

The Elmwood pasture contained large, old trees dominated by blue ash, bur oak, and chinquapin oak. These three species were prominent trees prior to Euro-American settlement of the Inner Bluegrass Region (IBR), and their assemblage has helped distinguished the IBR as "the most anomalous forest region in the Eastern U.S." (Braun 1950). Based on observations and research of the Inner Bluegrass by Braun and others (Bryant et al. 1980) it seems reasonable that some of the Elmwood pasture trees are timed with, or even pre-date, Euro-American settlement of Central KY, though without dendrochronology (tree ring) research it is impossible to say for sure. What can be said with certainty from looking at historical aerial imagery is that the loss of tree canopy coverage in the Elmwood pasture has been substantial over the last 60+ years, pointing to the need for planting the next generation.

Figure 3: Elmwood Stock Farm pasture as seen from KY NAIP 2020 2ft imagery (above) 1959 USGS imagery (below)

ELMWOOD TREES BY LAND USE: PASTURES

This loss of trees shown is notable, in both the context of the function of these large trees for the farm, and from an ecological and historical perspective. Blue ash (*F. quadrangulata*) is worth highlighting because the species was almost half (48.7%) of the trees in the Elmwood pasture, and has, along with bur oak and chinquapin oak, relevance in the Inner Bluegrass Region savannah-oak woodland community type. Blue ash is unique amongst ashes in that it thrives on limestone and upland soils, and relatedly, tolerates drought well (an attribute shared by all three key pasture species). Further, there is some evidence suggesting that blue ash is more tolerant of the invasive and highly destructive emerald ash borer than other ash species (Tanis & McCullough, 2012). During our inventory of the Elmwood pasture, we saw evidence of borer activity and blue ash decline. Depending on the health status of those trees today, it may be worthwhile to consider treatment options.

The importance of pasture trees in provisioning thermal comfort for farm livestock, coupled with observations that rotational livestock grazing has had a visibly positive effect on the health of the large pasture trees, deserves attention. The complexity of livestock, pasture and tree dynamics have led to entire fields of study and practice (e.g., agroforestry and silvopasture), and though an exhaustive review is beyond our scope, a few ideas on soil compaction and tree and rooting soil health seem worth brief exploration.

The effects of soil compaction on plants and trees are well known, and the maximum depth of impact forces of livestock hooves has been reported as variable – between 2 and 8 inches - dependent upon animal weight and soil moisture content (Hamza & Anderson 2005). Research on compaction and soil moisture is unanimously suggestive that the effects of soil compaction are greater and extend deeper into the soil profile at higher soil moisture content; i.e. wetter soils compact more easily (Soane et al. 1980).

Elmwood pasture containing mature, iconic Inner Bluegrass Region trees

Blue ash (*F. quadrangulata*) leaf

ELMWOOD TREES BY LAND USE: PASTURES

Potential management implications, including considerations of the length of exclusionary periods and the connection between livestock rotational grazing and soil quality are explored in Drewry's (2006) review of the effects of livestock treading and natural recovery of soils. The notion that animal exclusion from pasture promotes soil recovery after compaction presented in the review would have relevance for tree roots and be congruent with a current tree care practice of establishing tree protection zones (TPZ) during construction in more urban environments. TPZ best practices include establishing a physical barrier (i.e. fencing) around a tree during projects within which no construction activity (e.g. material or equipment storage, vehicular or foot traffic) occurs. Area of TPZs are usually determined based on a calculation using tree DBH. An ordinance in Lexington-Fayette Urban County Government (LFUCG Zoning Ordinance – Article 26), for example, states that TPZs should be 1 radial foot from a tree's trunk for each DBH inch up to 24 inches, and 1.5 radial feet for each DBH inch for trees larger than 24 inches; others have suggested that a TPZ area 12 times the trunk diameter is still inadequate to avoid physiological stress to tree (Benson et al., 2019). Perhaps the root of the TPZ question resides in knowledge of the lateral and vertical (to a lesser extent) spread of tree roots; lateral root extension measurements with ground penetrating radar have found tree roots to 1.25 times the crown extent (or dripline, introducing yet another metric for comparison) across several species (Sinacore et al. 2017) but anecdotal evidence of lateral root extension to much greater distances is abundant. In terms of rooting depth, 80-90% of root biomass for most trees globally (excluding those in extremely hot environments) is within 20 inches of the soil surface (Jackson et al. 1996). In summary, we mention all of this as a means to begin note sharing between tree and soil management across the urban-rural divide, with acknowledgement that: (1) soil compaction, soil moisture and tree/soil interactions are dynamically related in Elmwood pasture (and all other) trees, and (2) these considerations, along with the implementation of the practice of rotational grazing, seem worthy of follow-up within the context of the historic trees in the Elmwood pasture.

Finally, future pasture tree plantings should be considered if the once abundant shade (Figure 3) would be a valued amenity in years to come, given the fact that many of the trees in this site are aging and some (e.g., blue ash) are in decline. Physical protection of new seedlings will be necessary for tree establishment in pastures, and options are available through the forestry industry. We would recommend planting younger trees, saplings or "whips," which can be obtained at a lower price and when coming from reputable growers, will have intact root systems.

Photo obtained from Pexels.com

ELMWOOD TREES BY LAND USE: PASTURES

Another option to consider may be to collect and plant seeds (direct plant or propagate in greenhouse), or dig and transplant volunteer trees from the farm, perhaps even using historic pasture trees as seedstock. Densely planting young saplings and encapsulating the group within a single tree protection zone may be a good fit to (1) reduce costs by buying smaller stock, (2) minimize maintenance (i.e. mowing) edges (compared to plantings spread out across the pasture), and (3) overcome the inevitability of some amount of young tree mortality due to transplant shock. It is worth noting that high tree density will eventually affect the abundance and vitality of forage due to canopy growth and shading. Considering maximum growth expectancy in terms of both canopy width and height are critical steps in finding the "right tree for the right place." Ideally, a planted area could positively address some existing site issues, such as creating a riparian buffer near a drainage site or excluding some other "problem" area, and/or any other manner of incorporation into existing pasture layout and infrastructure. Another thought is to consider the large-canopied pasture trees as "anchor" trees within pasture reforestation sites, in effect shaping small forest patches and exclusionary areas around the large trees already present. Aspect and its role in shaping the benefits of tree shade is also relevant. In our hemisphere the impact of shade is most significant to the northeast of any tree on the landscape. Planting trees along the south and southwest fence lines in the pasture, for example, would eventually result in tree shade stretching to the north-northeast into this field during the summer months. As tree – but not livestock – experts, we assume that aspect and tree shade play significantly into how and where livestock congregate in the Elmwood pasture. Siting trees for the next 100 years (hopefully more) has many considerations, all needing to be weighed pragmatically in terms of managers' and animals' needs in relation to the current state of the pasture and other farm activities.

In conclusion, this Elmwood pasture is on a trend toward canopy decline (Figure 3), and without some planting intervention this will continue. Indeed, avoiding the outcome of a tree-less landscape is the reason Richards' (1983) suggests that the smallest trees (< 8 inch DBH) make up the largest proportion of a tree collection. If expanding the tree canopy in the pasture were initiated, one thought is that species selection could be guided by other Inner Bluegrass Region savannah-woodland sites. One such site is Griffith Woods Wildlife Management Area, less than 20 miles northeast of Elmwood. Several of Elmwood's pasture species, including chinquapin and bur oaks, along with black walnut are also found at Griffith Woods; in addition Griffith Woods has many large, old Shumard oaks (*Q. shumardii*) and several hickory species (*Carya spp.*) including shagbark (*C. ovata*), shellbark (*C. laciniosa*) and bitternut (*C. cordiformis*). These would all be fine choices for planting, and fit within current and historical (Braun 1950) observations of iconic species in the region.

ELMWOOD TREES BY LAND USE: FARM ROADS

KEY FINDINGS:

+ 251 trees measured, 17 species represented

+ Species composition and size distribution were idiosyncratic along the two farm roads, and even within sections of the same road

+ Hackberry and black cherry were abundant throughout but especially on the newer road, whereas older farm roads contained a greater diversity of species, including catalpa and black walnut

Photo obtained from Pexels.com

ELMWOOD TREES BY LAND USE: FARM ROADS

Diversity: Species and Size

Table 4: Elmwood's farm road tree species, and their relative abundance, relative basal area, and relative importance value of each species, sorted by relative importance value. "Other" is a catch-all for all other species that had less than 2% relative importance value.

Botanical Name	Common Name	# of trees measured	Species Relative Abundance (%)	Relative Basal Area (% of site total)	Relative Importance Value (%)
Prunus serotina	black cherry	73	29.1%	34.5%	31.8%
Celtis occidentalis	hackberry	84	33.5%	21.6%	27.5%
Catalpa speciosa	catalpa	27	10.8%	16.0%	13.4%
Juglans nigra	black walnut	33	13.1%	7.0%	10.1%
Acer saccharinum	silver maple	2	0.8%	7.4%	4.1%
Platanus occidentalis	American sycamore	3	1.2%	6.3%	3.7%
Gymnocladus dioicus	Kentucky coffee tree	8	3.2%	1.6%	2.4%
Robinia pseudoacacia	black locust	4	1.6%	2.6%	2.1%
	Other	17	6.8%	3.0%	N/A
	Total	251	100.0%	100.0%	N/A

On Elmwood roads, the importance values of four species surpass Santamour's (1990) recommended 10% threshold for any single species: black cherry (31.8%), hackberry (27.5%), catalpa (13.4%), and black walnut (10.1%) (Table 3). The 20% threshold for the genera taxonomic level was surpassed by cherry (*Prunus spp.*) (31.8%), as well as hackberry (*Celtis spp.*) (27.5%). The 30% threshold for the family taxonomic level was surpassed by Rosaceae (rose) (32.9%), predominantly black cherry with a few scattered hawthorns (*Crataegus sp.*).

ELMWOOD TREES BY LAND USE: FARM ROADS

Diversity: Species and Size

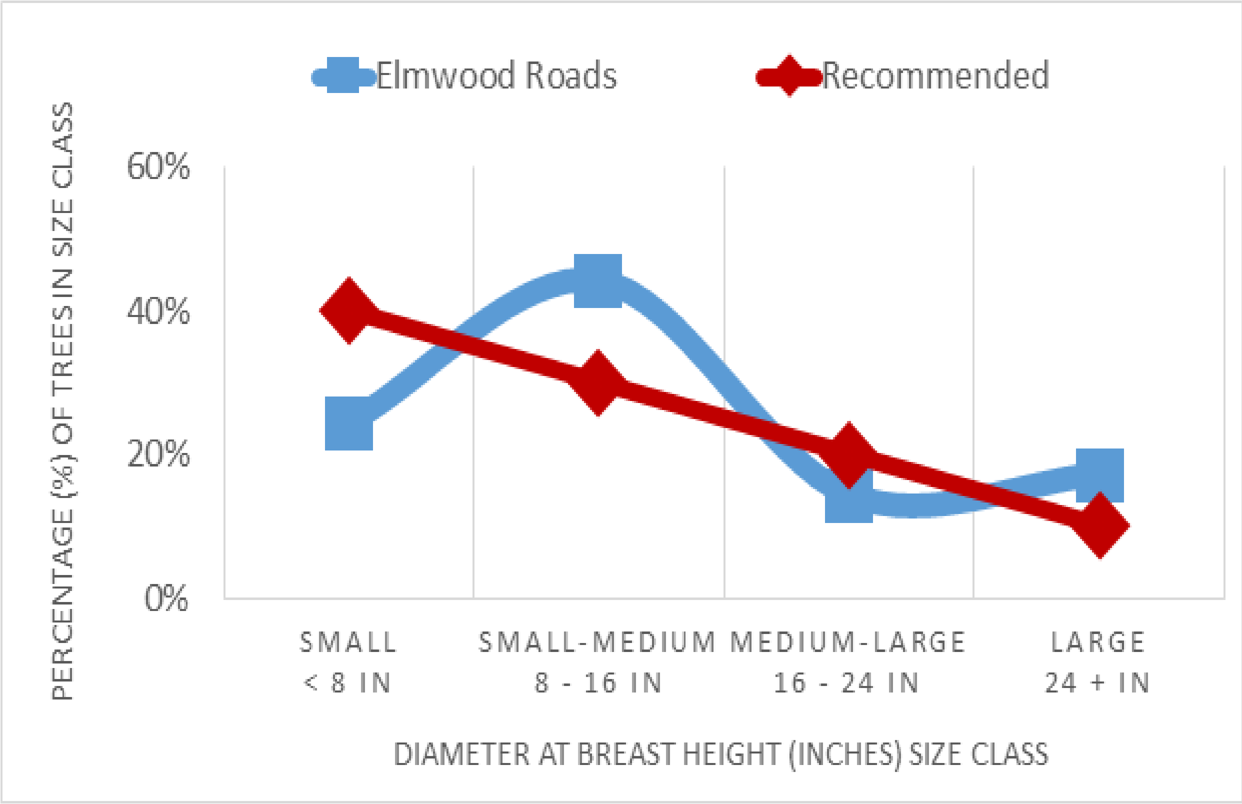

Figure 4: Size class distribution of Elmwood's road trees (blue line) compared to the recommended distribution (red line), the latter proposed by Richards (1983).

The tree size class distribution of the trees measured along Elmwood Stock Farm roads (Figure 4) illustrates that small trees (<8 inch DBH) were well below the Richards' (1930) recommended 40%, at 24.3%. Elmwood's roads trended higher for both 8-16 inch DBH (44.2% compared to recommended 30%) and 24 + inch DBH (17.1% compared to recommended 10%) size classes. Trees 16-24 inch DBH were slightly below the recommended 20% - at 14.3%. As will be discussed below, drawing generalities on tree size distribution from this information is nearly impossible without considering the nuances of each road, and in one case partitions within one road segment.

ELMWOOD TREES BY LAND USE: FARM ROADS

Management Considerations

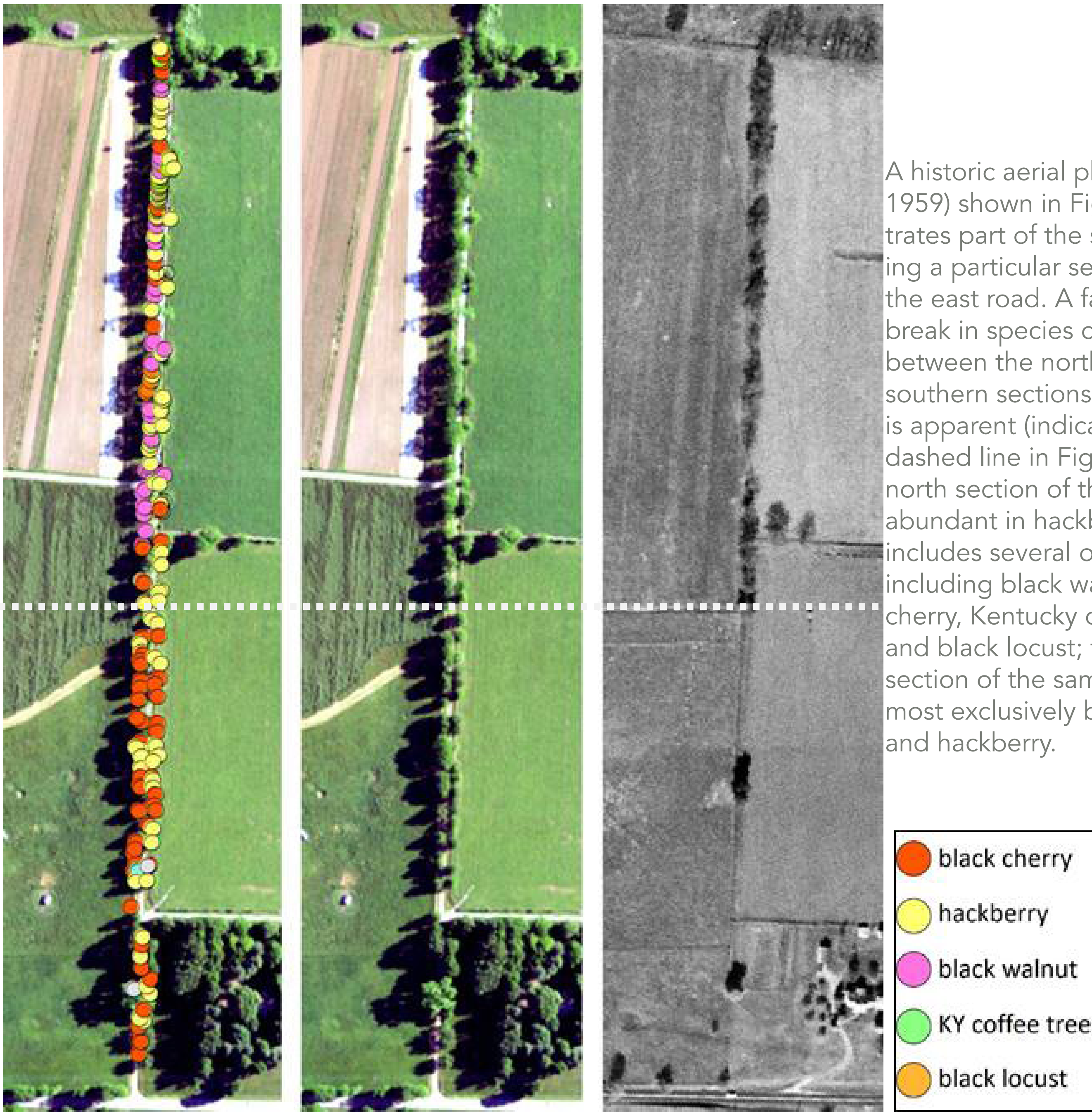

Figure 5: Trees inventoried along eastern road overlain on 2020 imagery (left); 2020 aerial imagery (middle); 1959 aerial photo (USGS)

A historic aerial photo (USGS 1959) shown in Figure 5 illustrates part of the story regarding a particular section along the east road. A fairly abrupt break in species composition between the northern and southern sections of this road is apparent (indicated by a dashed line in Figure 5). The north section of this road is abundant in hackberry and includes several other species including black walnut, black cherry, Kentucky coffee tree, and black locust; the south section of the same road is almost exclusively black cherry and hackberry.

ELMWOOD TREES BY LAND USE: FARM ROADS

In addition to connecting residences, communal work spaces and fields, farm roads and the trees that abut them illustrate some interesting landscape stories, if judged only by our inventory results along Elmwood Stock Farm's roads. The two main farm roads inventoried intersect US 460 (a major east-west highway through Kentucky and Virginia), are generally oriented in the north-south direction, and were selected for sampling due to the frequency of trees on either shoulder of the road. Rows of trees along inventoried roads were arranged in single-file, adjacent to crops fields or pasture on the non-road side, and occasionally associated with a fencerow. (Note: this suggests some grey area between "roads" and "fencerows," but our distinction is that the latter (next section) had no defined (i.e. graveled) lane for vehicular passage.) An abundance of black cherry and hackberry were found along Elmwood's roads; in fact, these two species had the highest importance values across all land use types on the farm except for the pasture.

Other on-site observations between the road sections beyond the assemblage of species included finding generally smaller trees bordering a two-track gravel road in the southern section compared with larger trees bordering a full gravel bed road in the northern section. The USGS aerial photo (right image in Figure 5) illustrates that the southern section was much less treed in the not-too-distant past (just over 60 years ago).

For our team, the abundance of black cherry and hackberry along this road section provides another example of these species' dominance as volunteer trees in Central KY, other examples being along county roads and suburban fencerows in nearby Fayette County. Hackberry is discussed at greater length in "Fencerows." Black cherry is notoriously intolerant of shade (Burns & Honkala 1990), and the fact that within each of these mentioned locales (including the southern portion of Elmwood's eastern road) the species is often found growing in linear, single-file patterns – thus receiving ample sun – may be a species characteristic worth considering. Of note is that the aggressive spread of black cherry has categorized this tree as an invasive species in several European countries, even prompting invasion ecology research findings of there being lower soil-borne pathogen pressure on black cherry in its non-native ranges in Europe (Reinhart et al. 2010). The success of both black cherry and hackberry as dominant volunteer species along this Elmwood road section and throughout our region is complex and worthy of further investigation.

Elmwood's eastern road near the break between northern and southern sections, looking south down the two-track gravel road.

ELMWOOD TREES BY LAND USE: FARM ROADS

Though black cherry and hackberry were plentiful, other species including northern catalpa and black walnut were significant road trees (with importance values of 13.4% and 10.1%, respectively). Black walnut is the more common of the two in Central KY, found across a range of sites from rural to urban settings, and has historical prevalence in the region (Braun 1950). Finding large, mature catalpa trees along the western road we surveyed - 56% were > 16 inch DBH and of those almost 30% were > 24 inch DBH - was an unexpected discovery. Catalpa is less common in the region, and its messiness from large leaves and seedpods has even earned the species a place in the "prohibited" section of a city planting manual (Lexington Street Tree Guidelines, Revised December 2016). Catalpa flowers and their associates, however, hold an important place in promoting insect diversity at Elmwood. This was brought to our attention by farm managers and is also apparent in a published study of catalpa pollinators which reported catalpa flowers and nectar attractive for bumble bees and carpenter bees, who visit flowers during the day, and more than a dozen species of moths, who more actively pollinate at night (Stevenson & Thomas 1977).

Photo obtained from Pexels.com

ELMWOOD TREES BY LAND USE: FARM ROADS

A historical perspective of catalpa on the other hand, reveals an exuberance over this species – bordering upon a historic viral phenomenon – that individuals such as Eliam Eliakim Barney and John P. Brown spurred on in the late 1800's through the early 1900's. These two horticulturalists' case for catalpa was interestingly entwined with the U.S. railroad industry. Barney, operator of Barney and Smith Car Company in Dayton, OH., compiled and published observations from many individuals around the country on catalpa and its wood properties. His horticultural and industrial endeavors led him to conclude that there was "no one tree I would as soon use for the entire structure of a [railroad] passenger car, including sills, plates, posts and the entire framework" (Barney 1879). A few decades later Brown, in the June 1905 issue of Arboriculture (a monthly publication from the International Society of Arboriculture of which he was editor and publisher), chronicled his effort in planting 203,000 catalpa trees (with hired help) in Carney, AL for the Louisville and Nashville Railroad Co. (Brown 1905). The supposed qualities of catalpa wood including fast growth, resistance to decay, and compression strength were suggested as positioning this species as a perfect substitute for more coveted (and thus disappearing) species like white oak and American chestnut due to a cross-country demand for wood, driven in large part by the railroad industry. These same virtues (their suggested magnitude now questionable in hindsight) were heralded by catalpa enthusiasts for another utility - as fence posts - that was more relevant for livestock farms around the country like Elmwood. Could it be that the road lined with mature catalpa was planted in connection with this historical exaltation of the species? The size of many individuals (6 trees were ≥ 30 inch DBH) would suggest that several of Elmwood's road-bordering catalpa's are centenarians at least, but without a dendrochronological study we can't be sure. Considering the seemingly intentional siting of the catalpas along the shoulders of the farm's western road, the historic range map of catalpa indicating a presence in far Western KY near the confluence of the Mississippi and Ohio Rivers, and Braun's (1950) compilation of historical botanical observations, we can say with some confidence that the species was not historically prevalent in the Bluegrass Region. Therefore, Elmwood's catalpas are almost assuredly human-introduced, though our understanding of the timeframe and motivation are only conjecture without additional work.

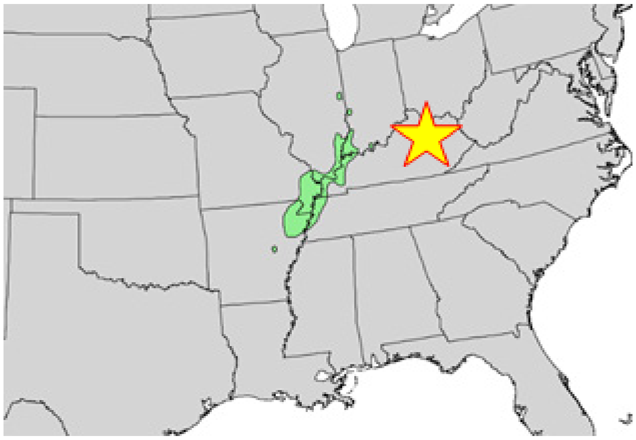

Figure 6: Catalpa (*C. speciosa*) species range (USFS, Little) and Elmwood location shown by yellow star

ELMWOOD TREES BY LAND USE: FENCEROWS

KEY FINDINGS:

+ 108 trees measured, 7 species represented

+ Dominated by hackberry

+ Mature hackberry and cherry trees dominate along sampled fencerows; other notably large bur oaks and black locust present

Photo obtained from Pexels.com

ELMWOOD TREES BY LAND USE: FENCEROWS

Diversity: Species and Size

Table 5: Elmwood's fencerow tree species, and their relative abundance, relative basal area, and relative importance value of each species, sorted by relative importance value. All fencerow trees measured (n=108) are included here.

Botanical Name	Common Name	# of trees measured	Species Relative Abundance (%)	Relative Basal Area (% of site total)	Relative Importance Value
Celtis occidentalis	hackberry	72	66.7%	54.3%	60.5%
Prunus serotina	black cherry	9	8.3%	20.0%	14.2%
Robinia pseudoacacia	black locust	13	12.0%	12.7%	12.4%
Quercus macrocarpa	bur oak	8	7.4%	9.4%	8.4%
Juglans nigra	black walnut	3	2.8%	1.5%	2.1%
Carya sp.	hickory	1	0.9%	1.2%	1.1%
Ulmus americana	American elm	1	0.9%	0.9%	0.9%
Carya laciniosa	shellbark hickory	1	0.9%	0.0%	0.5%
	Total	108	100.0%	100.0%	100.0%

Looking at the importance values of Elmwood's fencerow trees species, two surpass Santamour's (1990) recommended 10% threshold for any single species: hackberry (60.5%) and black locust (12.4%) (Table 5). Being the only species in both the hackberry genus – *Celtis* - and family - Cannabaceae – hackberry's 60.5% importance value also surpassed both recommendations for genera and family proposed by Santamour (1990).

ELMWOOD TREES BY LAND USE: FENCEROWS

Diversity: Species and Size

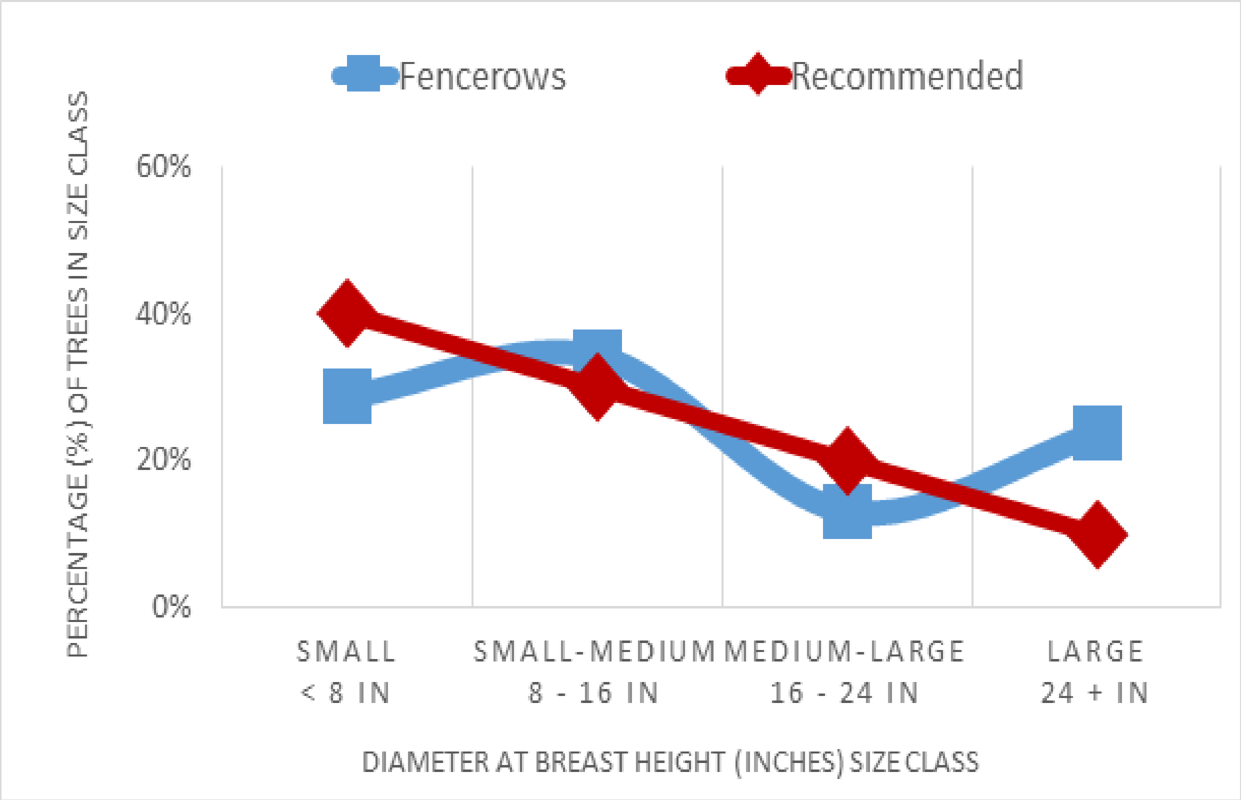

Figure 7: Size class distribution of Elmwood's fencerow trees (blue line) compared to the recommended distribution (red line), the latter proposed by Richards (1983).

The size class distribution of the trees measured along Elmwood's fencerows (Figure 7) illustrates that small trees (<8 inch DBH) were below the Richards' (1983) recommended 40%, at 28.8%. Fencerows trended higher in the small-medium (8-16 inch DBH) category, with 34.2% compared to the recommended 30%. Medium-large (16-24 inch DBH) trees were below the recommended, with 13.2% to 20%, respectively. Large (24+ inch DBH) fencerow trees were plentiful, more than double the recommendation, with 23.7% compared to 10%.

ELMWOOD TREES BY LAND USE: FENCEROWS

Management Considerations

The utility of fencerows to delineate field and pasture, along with the costs associated with their establishment and maintenance, are a constant consideration for farms like Elmwood. Fencerows that are treed act as windbreaks with many micro-climatic effects (see review by Brandle et al. 2004), serve as habitat for natural enemies of agricultural pests (see review by Bianchi et al. 2006) and pollinators (Stevenson & Thomas 1977), all which are of seeming importance to Elmwood's livestock and crop operations. The assemblage of trees along Elmwood's fencerows was another unique landscape element in our analysis of Elmwood's tree community.

The most obvious takeaway along the Elmwood fencerows we measured was the abundance of hackberry, a species which accounted for 2 of every 3 fencerow trees measured. The multitude of fencerow hackberries factored into this tree species having the overall highest importance value in not only the fencerows but also out of all Elmwood trees in our analysis (Table 1). Some attention seems to be due to this omnipresent species, on the farm and throughout the Central KY region.

Hackberry has wide distribution throughout the eastern and Midwestern U.S., is tolerant of a range of climates including both periodic flooding and drought, shade and can be long-lived (Burns & Honkala 1990). Regarding historical presence, Braun (1950) relays accounts of hackberry in multiple early botanical observations by Euro-American settlers, suggesting the importance of this species in Central KY forest patches for at least the past several hundred years. Though some have adopted and promoted more charismatic and iconic species assemblages (i.e., those found in Elmwood's pasture) in the IBR, the hardy characteristics of hackberry have seemingly held up this species over the tests of time, and weather, as an important species in community forests at Elmwood and throughout the region.

Along Elmwood's fencerows, we again find hackberry and black cherry as important volunteer species and thus they again seem deserving of mention, as here these two species accounted for 7 of the 9 exceptionally large (DBH > 3 feet) fencerow trees that we measured (along with a bur oak and black locust). A direct comparison of black cherry and hackberry is difficult, as the characteristics and ecology of black cherry have been more widely studied than hackberry, likely due to the utility of the former for its use in veneer and furniture wood. Aligning with observations of the Elmwood fencerow tree groupings, most black cherry seeds fall within the vicinity of the parent plant and so it has been observed that seedling advancement depends mostly on location of seed-producing individuals (Burns & Honkala 1990). Black cherry's intolerance for shade has been mentioned, but the species also has an affinity for lower pH soils and is less tolerant than hackberry to varied environmental conditions including shading, flooding and drought (Burns & Honkala 1990).

ELMWOOD TREES BY LAND USE: FENCEROWS

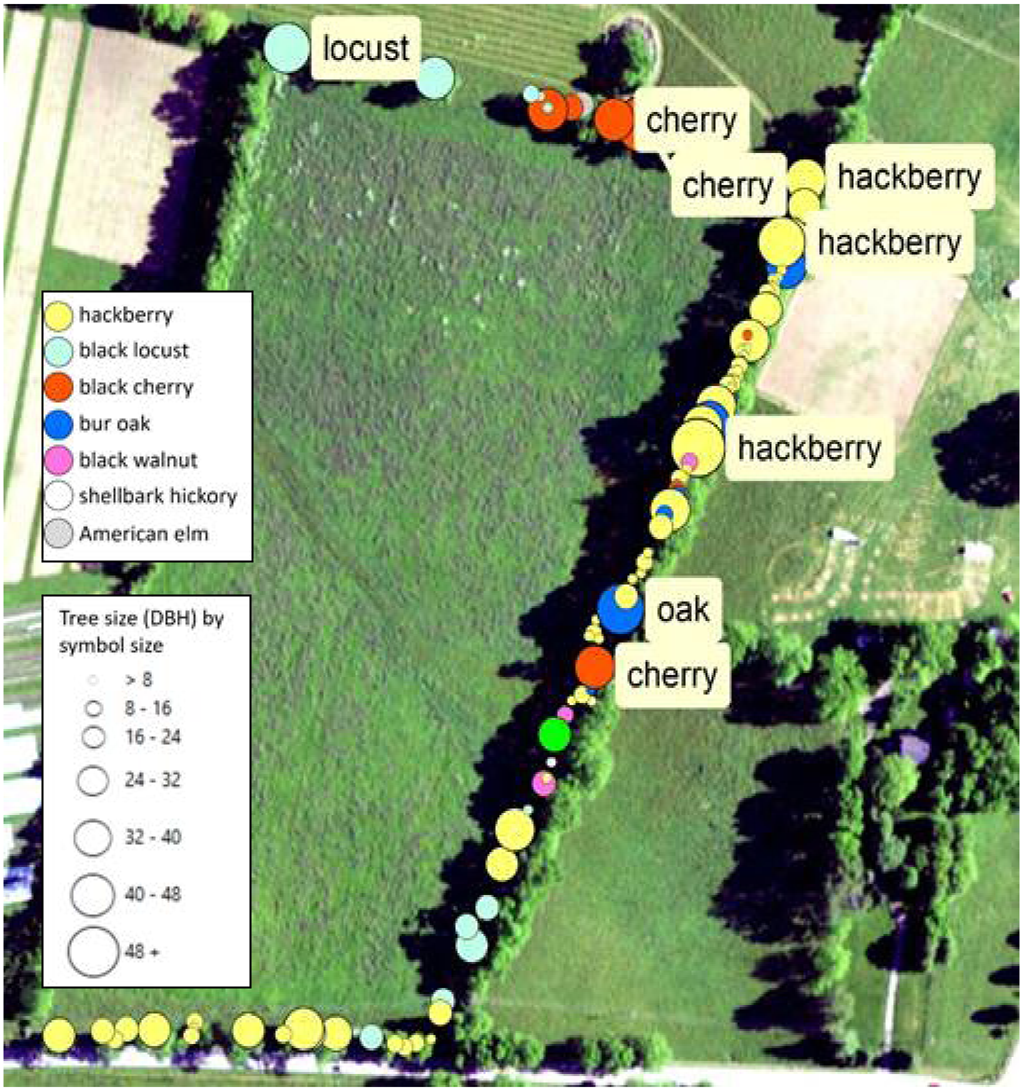

Figure 8: Elmwood's fencerow trees (dots) and species (dot colors shown in legend); DBH is illustrated by size of dots (shown in lower legend), with larger trees having larger dots. The largest 9 trees, with DBH > 36 inches, are labeled with common name, and these individuals seem to be driving the spatial patterns of species groupings.

A study looking across the Eastern U.S. similarly noted the prevalence of black cherry and hackberry on agricultural land, their species characteristics (e.g. rapid growth and reproduction) lending to their success, and the observation that release of these native species in cleared agricultural landscapes has over time promoted their dominance since Euro-American settlement (Hanberry 2022). The prevalence of these two species at Elmwood and around the region as volunteer trees again seems worth further investigation, particularly considering climate pressures and their potential effects. For instance, are hackberry's more generalist site requirements advantageous over black cherry as climatic (e.g., flooding and drought) stressors become more frequent? Climatic stressors are a reality that all urban and community forests will face (IPCC 2019). Other stressors such as soil disturbance and compaction may also be important considerations for the prevalence of these and all species in the region if not immediately to Elmwood's trees, then certainly to the urban development and associated tree canopy changes in nearby Georgetown, KY.

ELMWOOD TREES BY LAND USE: HOMESTEADS

KEY FINDINGS:

+ 230 trees measured, 32 species represented
+ Greatest number of tree species out of all land use type
+ Intentional plantings interspersed with volunteer and legacy trees

Photo obtained from Pexels.com

ELMWOOD TREES BY LAND USE: HOMESTEADS

Diversity: Species and Size

Table 6: Elmwood's homestead tree species, along with their relative abundance, relative basal area, and relative importance value of each species, sorted by relative importance value. "Other" is a catch-all for all other species that had less than 2% relative importance value.

Botanical Name	Common Name	# of trees measured	Species Relative Abundance (%)	Relative Basal Area (% of site total)	Importance Value (%)
Celtis occidentalis	hackberry	74	32.2%	23.1%	27.6%
Prunus serotina	black cherry	31	13.5%	6.6%	10.1%
Juglans nigra	black walnut	14	6.1%	3.6%	9.2%
Pinus strobus	white pine	13	5.7%	2.3%	6.6%
Acer saccharinum	silver maple	11	4.8%	13.7%	5.2%
Catalpa speciosa	catalpa	9	3.9%	1.2%	4.9%
Acer saccharum	sugar maple	8	3.5%	6.4%	4.8%
Fraxinus quadrangulata	blue ash	6	2.6%	6.3%	4.5%
Robinia pseudoacacia	black locust	6	2.6%	5.3%	4.0%
Malus sp.	crab apple	6	2.6%	0.5%	4.0%
Quercus macrocarpa	bur oak	5	2.2%	8.3%	2.6%
	Other	47	20.4%	22.7%	N/A
	Total	230	100.0%	100.0%	N/A

Elmwood's homesteads had the greatest tree species diversity on the farm. Similarly to roads and fencerows, two species had high importance values - hackberry (27.6%) and black cherry (10.1%), surpassing Santamour's (1990) recommended 10% threshold for any single species. The hackberry genus – Celtis, also surpassed the 20% recommendation for a single genus (Santamour 1990) – at 27.6%.

ELMWOOD TREES BY LAND USE: HOMESTEADS

Diversity: Species and Size

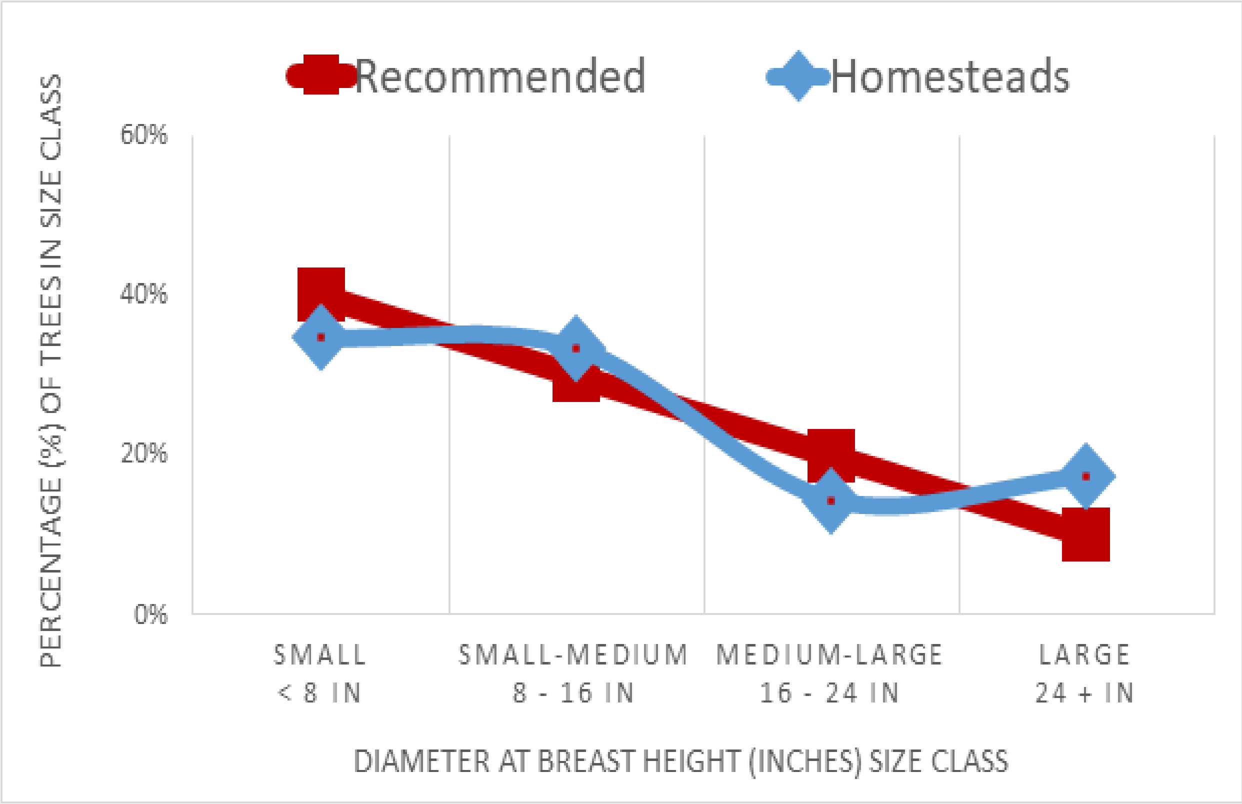

Figure 9: Size class distribution of Elmwood's homestead trees (blue line) compared to the recommended distribution (red line), the latter proposed by Richards (1983).

Out of the 4 land use types, Elmwood homesteads were most closely aligned with Richard's (1993) recommended size structure. The size class distribution of the trees measured around Elmwood's homesteads (Figure 9) illustrates that small trees (< 8 inch DBH) were slightly below the Richards' (1983) recommended 40%, at 34.8%. Homesteads trended slightly higher in the small-medium (8-16 inch DBH) category, with 33.5% compared to the recommended 30%. Medium-large (16-24 inch) trees were slightly below the recommended, with 14.3% to 20%, respectively. Large (24 + inch DBH) homestead trees were more plentiful, with 17.4% compared to 10%.

ELMWOOD TREES BY LAND USE: HOMESTEADS

Management Considerations

Homestead trees, or the trees around human living, working, and communal spaces, at Elmwood Stock Farm play an important role in everyday life. Our "homestead" designation included trees near communal areas including a packing shed and farm staff kitchen area, equipment barns, worker housing, and two farm estates. At each of these homestead sites, tree canopy seemed to enhance livability and workability, most obviously by providing shade and windbreak. One home area was omitted from our inventory because of the lack of trees close to the home (which not incidentally is the homestead with solar panels).

Tree diversity around homesteads was highest of all land use types with a total of 32 species (compared to as few as 8 species found along fencerows and in the pastures). Hackberry and black cherry were most numerous, together accounting for the majority of the homestead trees we measured (Table 6). The regional prevalence of these two species is explored in both the "Farm Roads" and "Fencerows" sections. It seems important to note here that the location of hackberry and black cherry within homestead areas was often along the periphery of dwellings and structures, for example along existing or suggested homestead fences, which may highlight an opportunity for more precise and nuanced land use designations in future work. Figure 10 shows this observation, along with the trend of high tree species diversity around one of the farm's homestead sites.

Figure 10: High tree species diversity was found around homesteads, including this farm estate house.

ELMWOOD TREES BY LAND USE: HOMESTEADS

Several taxa were found around homesteads that were much less frequent to non-existent in the other land use types of our tree survey. Maple (specifically silver maple and sugar maple) were more abundant around homesteads (23 trees) than other land use types (5 trees total - all along roads). The majority of homestead maples were (1) large, > 20 inches in diameter (18 out of 23 measured trees), and (2) located around two farm estate houses (22 out of 23 trees). Other novel homestead taxa were 21 conifers, including white pine (13), Norway spruce (4), eastern redcedar (3) and one eastern hemlock. Notably, these were the only conifers we measured in our farm survey. Additional species found around homesteads that were novel in our farm survey though quite common in more urbanized sites included crabapples, dogwoods, and ornamental cherries. The novel homestead species we measured must be the result of intentional planting, likely related to a sustained effort to enhance the aesthetics (e.g. maples for fall color and dogwoods for spring flowers) and livability (e.g. evergreens for privacy and windbreaks) of the dwellings and workspaces at Elmwood.

A couple of large legacy trees whose size and form suggest alignment with or perhaps pre-dating the establishment of farm structures, included a blue ash and bur oak near homesteads. One example was an awe-invoking bur oak with a 44-inch diameter located on the west side of one of Elmwood's barns. Similar to the pasture, these massive trees provide a glimpse at both the legacy connected to the historic Elmwood farm but also the greater Inner Bluegrass Region.

The planting of a variety of species, in tandem with the presence of legacy trees and volunteer species, provides us with our best guess as to the high tree species diversity at Elmwood's homesteads. In a review of biodiversity studies in the context of urbanization, McKinney (2008) noted that in the urban environments (which out of all land use types at Elmwood the homesteads would be most closely aligned) plants are often found to be more diverse than surrounding rural areas. Connections between urban plant diversity and socioeconomic status have been observed, and have even engendered the phrase "luxury effect" in urbanized environments (Hope et al. 2003). Similar studies point to the draw of promoting diverse plants in human-built landscapes, which was our essential observation around Elmwood's homesteads.

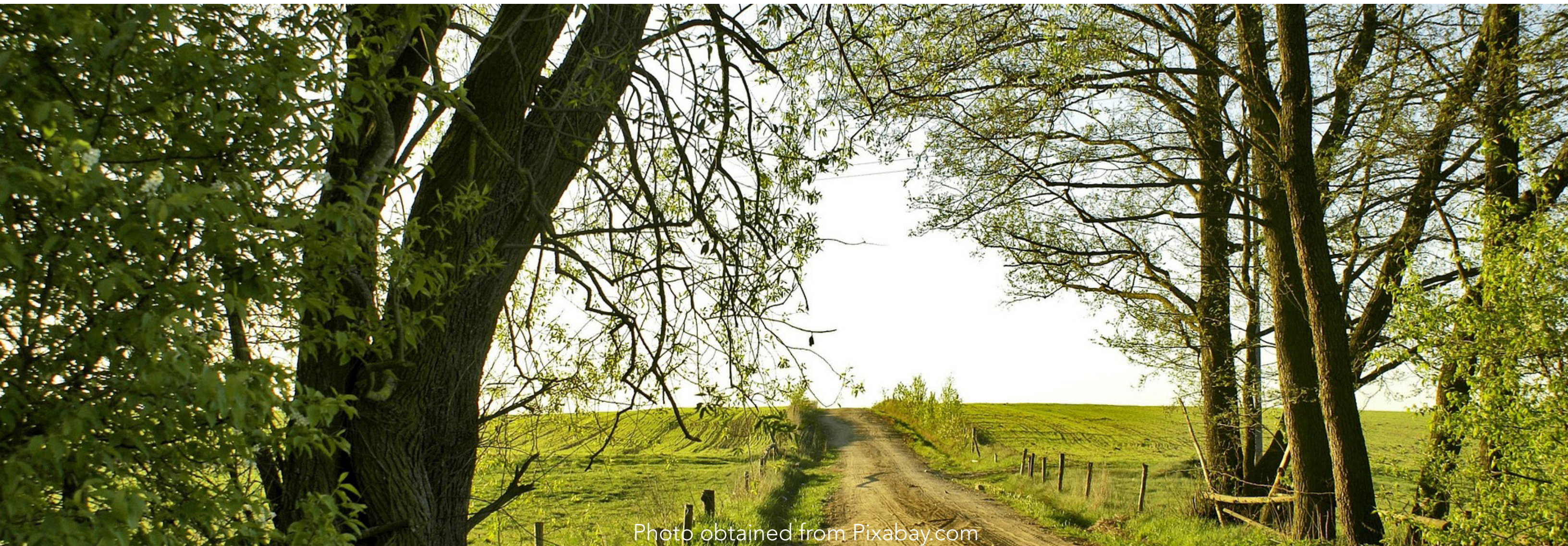

Photo obtained from Pixabay.com

CONCLUSION

Our exploration of the trees at the Elmwood Stock Farm has been quite a journey, coinciding with the COVID-19 pandemic and all its fallout. Our project timeline was significantly modified and progress on this project has been incremental. Even so, each step forward in assessing Elmwood's treed landscape has illuminated nuanced findings and additional questions. The process of delineating trees based on the 4 land use types, coupled with the communication with farm management regarding land use history set the stage for discoveries that would have otherwise been overlooked in our approach. A commonality through this investigation of trees is the important role of land use history in shaping the tree canopy we see at Elmwood today. We saw this in the Elmwood pasture, whose mature Inner Bluegrass trees have been providing shade and other benefits to animals (including humans) for hundreds of years, but where the tree canopy is disappearing. We saw this along Elmwood's roads, where intentional plantings like catalpa now tower over the old road and small volunteers like black cherry have filled in a more recent farm road. We saw this along fencerows, where several very large black cherry and hackberry and their progeny have been dominating and shaping the canopy for some time. We see it around Elmwood's homesteads, with trees from all the other land use types plus several novel species whose selection would seem to fill other human needs, like the need for beauty and privacy.

It seems timely, in our closing thoughts which focus on land use history, to consider the continuum of human settlement influencing to this "most anomalous forested region in the eastern U.S." (Braun 1950). Just south of Elmwood across U.S. 460 flows the North Elkhorn Creek, and if one were to follow the creek upstream about 10 miles and scramble up its steep bank they'd find some curious earthen mounds in Adena Park. This is one of several sites where archeological evidence of the Adena people, inhabitants of Central KY during the Woodland Period (1,000 BCE – 400 CE), and here specifically a large earthen burial mound, can still be seen today (Lewis 2015). This mound, the thinking goes, suggests a sacred resting place and a territorial permanence for the Adena living here so many years ago. Other artifacts including sharpened stone tools, pottery and fabric further paint our historical picture of these people, their life ways, and their reliance on the available local resources.

CONCLUSION

Elmwood Stock Farm is storied, and with this project we put forth the trees in its pasture, along its roads and fencerows, and around its homesteads as the main characters. Elmwood's tree canopy tells stories of old, those more recent, and some new and pressing – like a changing climate. The soil within which each Elmwood tree is rooted is similarly storied and is equally as important for the most massive oak as it is for the perennial tomato and the foraging animal. We've explored some of this here, and in doing so raised many new questions. This tree investigation has been both challenging and rewarding and made possible by generous support from Elmwood Stock Farm and funding through a UK Sustainability Challenge Grant. We hope that this report is as useful for its reader as it was for us, the UFI team.

Photo obtained from kentuckytourism.com

APPENDIX I

Aerial image of Elmwood Stock Farm (outlined in light blue) as seen from 1959 USGS air photo.

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