Comprehensive Management Plan

for

Mill Branch Park

Goshen, AR

Prepared for the City of Goshen

Washington County, Arkansas

By Beaver Watershed Alliance

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Beaver Watershed Alliance

Version 1:

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Contents

Executive Summary

Purpose of this Plan

This document presents a voluntary comprehensive management plan developed by the Beaver Watershed Alliance (Alliance) for the City of Goshen and property of Mill Branch Park, Goshen, AR. This plan intends to serve as a watershed-based, foundational piece to inform the future development of Mill Branch Park. This plan includes voluntary watershed management recommendations and techniques, water quality aspects to be considered, natural infrastructure(s) identified, and habitats/species identified to aid in long-range planning efforts while helping to promote long-term Source Water Protection. This management plan is intended to consolidate site inventories conducted to date and the recommendations made through various correspondences with local agencies, organizations, and subject experts into a comprehensive management plan. This is an ongoing, adaptive management plan for Mill Branch Park, to be referenced by City of Goshen officials and staff as well as act as a guiding document for voluntary land-management practice recommendations for the various challenges and opportunities available at this site.

The scope of this plan's development was from March 2021 through March 2022. Several partner agencies and organizations contributed time and resources to this plan; its success can be attributed to their efforts, as well as the emphasis on voluntary action for cities, landowners, and stakeholders – an approach which can serve as a model for future efforts by Beaver Watershed Alliance and programs by other cities, organizations, and agencies.

Credits

This plan was developed by Alliance staff, in partnership with the City of Goshen, with funding from the Walton Family Foundation and Beaver Water District. The Arkansas Archaeological Survey provided historical information for the site. Other organizations, such as the Arkansas Game and Fish Commission, Arkansas Department of Agriculture – Forestry Division, H2Ozarks, and The Nature Conservancy, provided in-person visits to the site with recommendations made in this plan.

Alliance's Role & Background

Beaver Watershed Alliance is a 501c3 non-profit watershed organization; its mission is to proactively protect, enhance, and sustain the water quality in Beaver Lake and the integrity of its watershed. The Alliance was formed in 2011 to establish programming to maintain high-quality drinking water in Beaver Lake and improve water quality on the Beaver Lake watershed. The Alliance represents a diverse stakeholder group from conservation, education, water utilities, technical and science, business, agriculture, recreation, local government, private landowners, and volunteer groups working together for the cause of clean drinking water. Through outreach and education, technical assistance, best-practice implementation, and planning/analysis activities, the Alliance works to advance source water protection for the Beaver Lake watershed. Beaver Lake serves over 500,000 residents with clean, fresh drinking water, provides hydroelectric power generation, and fuels the economy of NWA for business, industry, recreation, and tourism. For more information about the Alliance or the Beaver Lake watershed, please visit www.beaverwatershedalliance.org.

Watershed Area

Mill Branch Park is in the Beaver Lake watershed, defined as all lands which drain into Beaver Lake and above Beaver Dam. The Beaver Lake watershed is 764,428 acres (or approximately 1,200 square miles) in land area and consists of seven constituent watersheds (Fig. 1). The waters of the Beaver Lake watershed and the White River successively tribute to Table Rock and Bull Shoals lakes within the greater White River Subbasin in Missouri, forming a confluence of the Mississippi River near the town of McGehee, eventually draining into the Gulf of Mexico. The Beaver Lake watershed is further subdivided into constituent subwatersheds; Mill Branch Park is situated in the Dry Creek subwatershed, the lowest, in terms of elevation, of four constituent subwatersheds of the Richland Creek watershed (Fig. 2).

It should be noted Mill Branch, despite being in the Dry Creek subwatershed, is itself a headwater system - its confluence with Richland Creek occurs at roughly two stream miles below the confluence of its parent subwatershed, Dry Creek, with Richland Creek. Because of its positioning as a headwater tributary, the Mill Branch drainage area is effectively isolated from the rest of the Richland Creek watershed. Any watershed analysis for the Mill Branch drainage area should use its

confluence with Richland Creek for any modeling or monitoring considerations, rather than Dry Creek.

The Beaver Reservoir is one of ten priority watersheds in the Arkansas Nonpoint Source Management Program. The Arkansas Department of Energy and Environment has listed multiple stream segments in the Beaver Lake watershed in its list of impaired waters due to impaired water quality associated with the region's growing population, subsequent land-use change, and impairment of surface waters. The Beaver Lake watershed is also designated as a nutrient-surplus area by the Arkansas Department of Agriculture – Natural Resources Division.

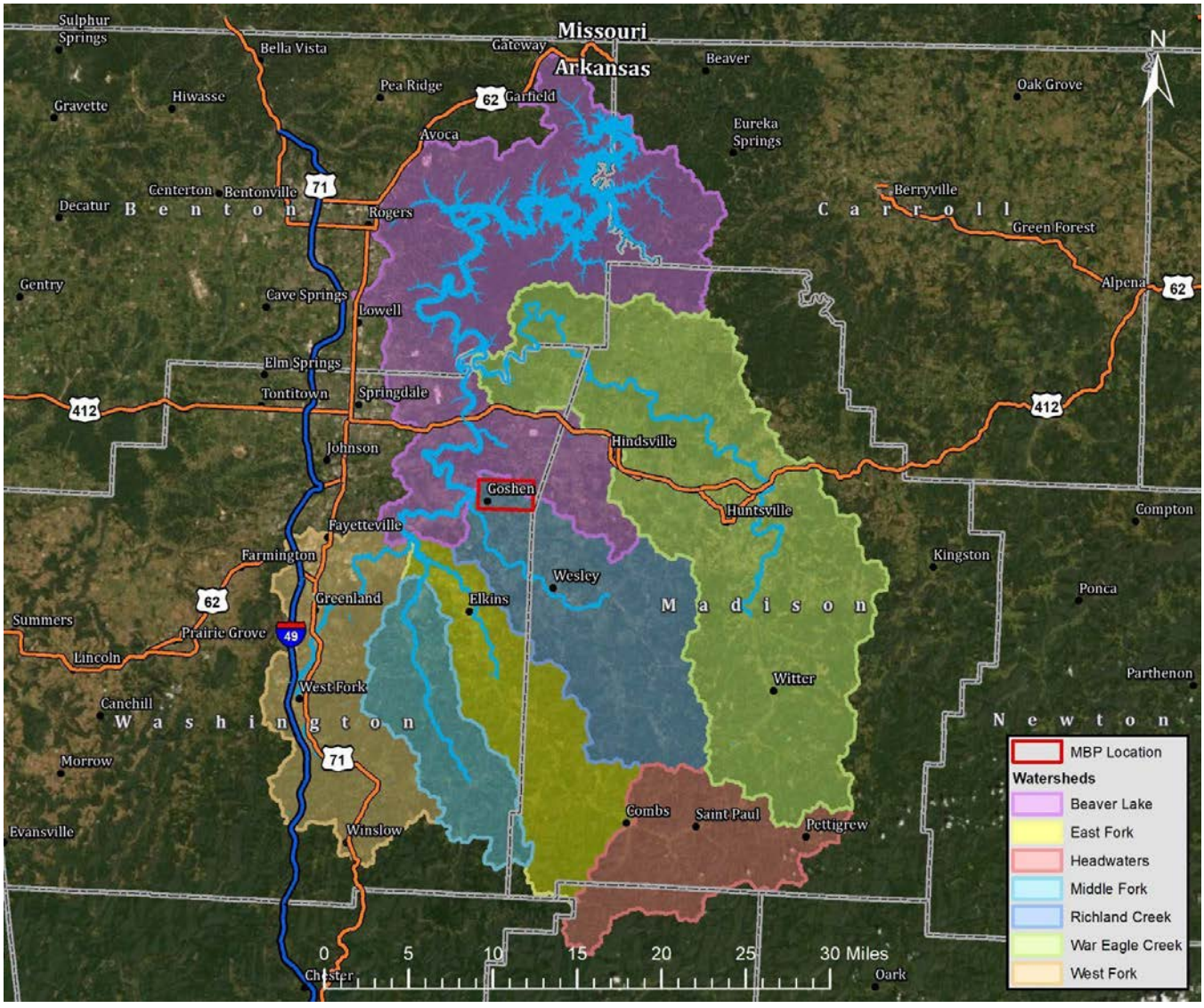


Figure 1: The Beaver Lake watershed, its seven constituent subwatersheds, and the primary river drainages which contribute to Beaver Lake (only 5th-order rivers and above are shown for clarity).

Communities can help reduce nonpoint source water contaminants like sediment and nutrients associated with land-use change by incorporating green infrastructure projects into developments. These projects facilitate natural ecological processes like stormwater filtration, nutrient cycling, and sediment capture. Installing constructed features which simulate these ecological features, augmenting existing natural features, or a combination thereof, helps mitigate damage, degradation, or destruction of these ecological functions, reduces the escalation of problems like erosion downstream, and increases the watershed's resistance to future damage as well as its resiliency in recovering from damage. The guiding principle is to integrate development with the landscape's natural processes. In stormwater's case, spread it out and slow it down.

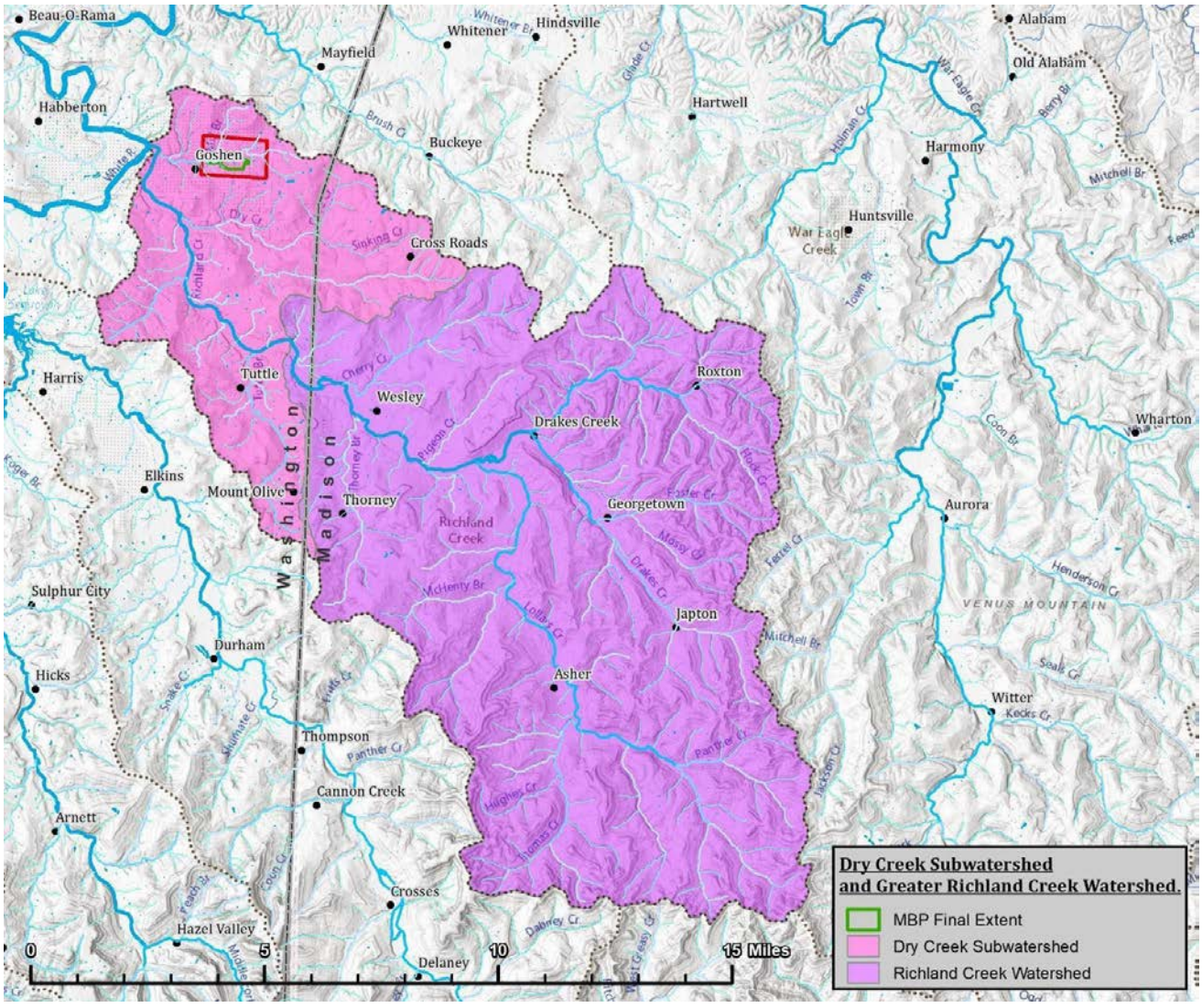


Figure 2: The Dry Creek subwatershed of Richland Creek. Mill Creek itself drains into Richland Creek before meeting Dry Creek. Headwater drainages like Mill Branch are critical for water quality, as they have the greatest ratio of land-to-water interaction.

Site Location

Mill Branch Park is located in Washington County, AR., approximately 10.3 miles east-north-east of the city of Fayetteville in the NW. Within the Public Land Survey System, the park is in Township 17N, Range 28W, and Sections 28, 29, 32, and 33 within the Goshen Quad. The bulk of the park rests within the NE¼ of Section 32 and NW¼ of Section 33 (Fig. 3). As of the completion of the first version of the management plan in January 2022, the current extent of Mill Branch Park is approximately 19.2 acres. The centroid coordinates of the park's final extent are 36.103796, -93.977767. As part of a five-year plan to acquire adjacent tracts, the final extent of Mill Branch Park will comprise approximately 101.5 acres. All recommendations made in this plan shall be understood by the reader to be for the final extent (101.5 acres) of the park (Fig. 3).

Directions to Site

Mill Branch Park is approximately 10.3 miles east-north-east of Fayetteville and slightly east of Goshen itself along East Bowen Boulevard. As of the completion of this management plan, Mill Branch Park does not possess a road number. An unnamed gravel road owned by the City of Goshen currently provides access to the park and is located along East Bowen Boulevard approximately 2,406ft., slightly less than 0.5 miles, east of the Goshen post office at 36.103750, -93.985083. The entrance is on the south side of East Bowen Boulevard, just 75 feet west of Paul Pray Drive and easily missed as the area is densely vegetated.

From the intersection of East Mission Boulevard and North Crossover Road (Walgreens on the southeast corner) in Fayetteville, head east on East Mission Boulevard 8.0 miles towards Goshen and Huntsville. East Mission will become West Bowen Boulevard just before Habberton Road. Continue 1.1 miles east, past the Goshen post office, and take the third right after North Church Street onto the park access road going south. Cross Mill Branch Creek and continue straight for 900 feet past the house on the right and through the gate. As of completion of this plan, parking is primarily at the base of a demolished poultry shed. It should be noted, approximately 20 feet south of the gate below the poultry house, there is a band which is private property extending approximately 85-95 feet east of the fence.

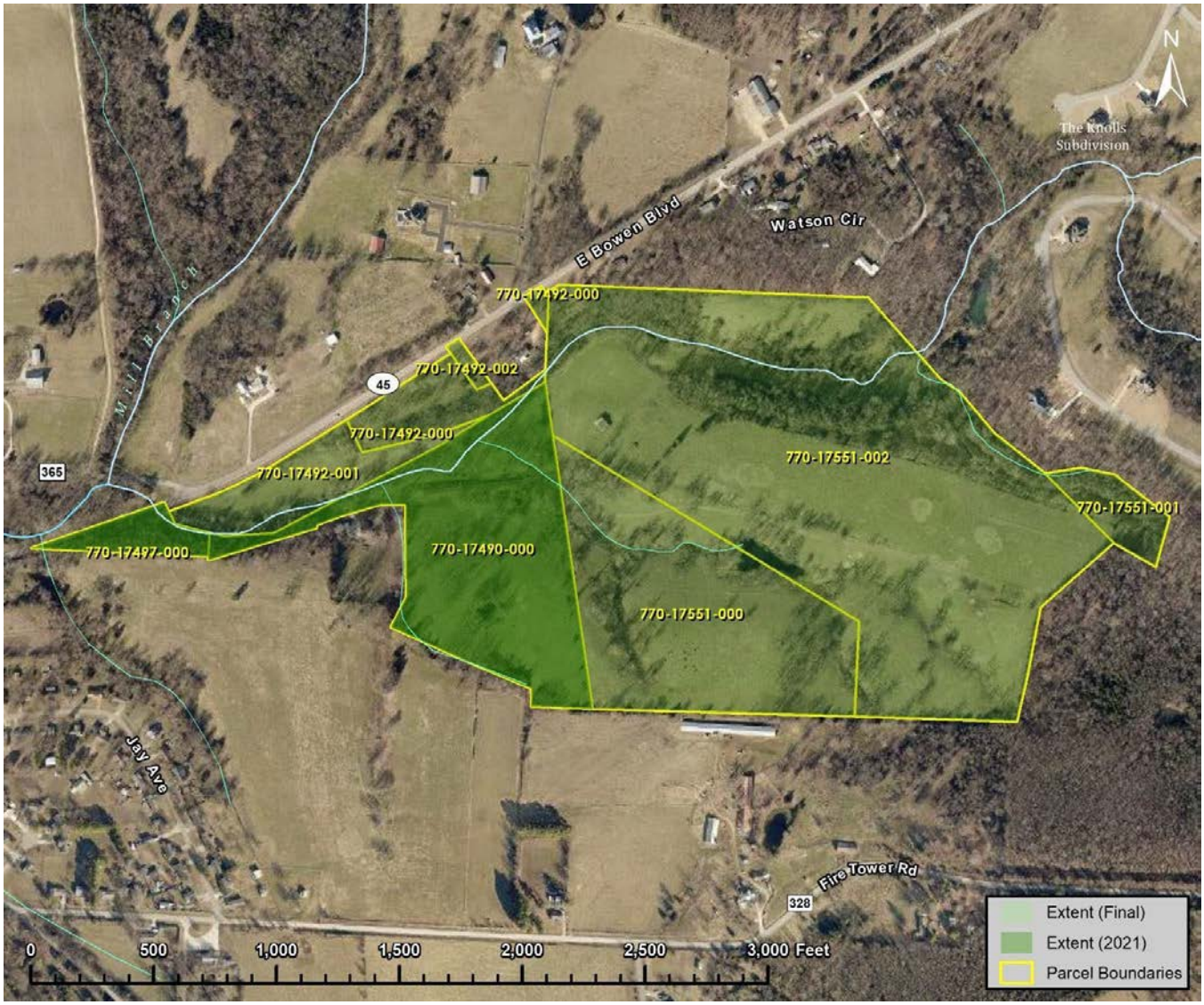


Figure 3: Mill Branch Park's extent, as of winter 2021 (dark green), and parcels to be included in the final extent of Mill Branch Park (light green).

Site History

(With contributions by J.J. Lockhart)

Historic Use

Rural land in the United States has historically been transferred from federal ownership to private ownership through land grants called patents, primarily in 40-acre increments issued by the

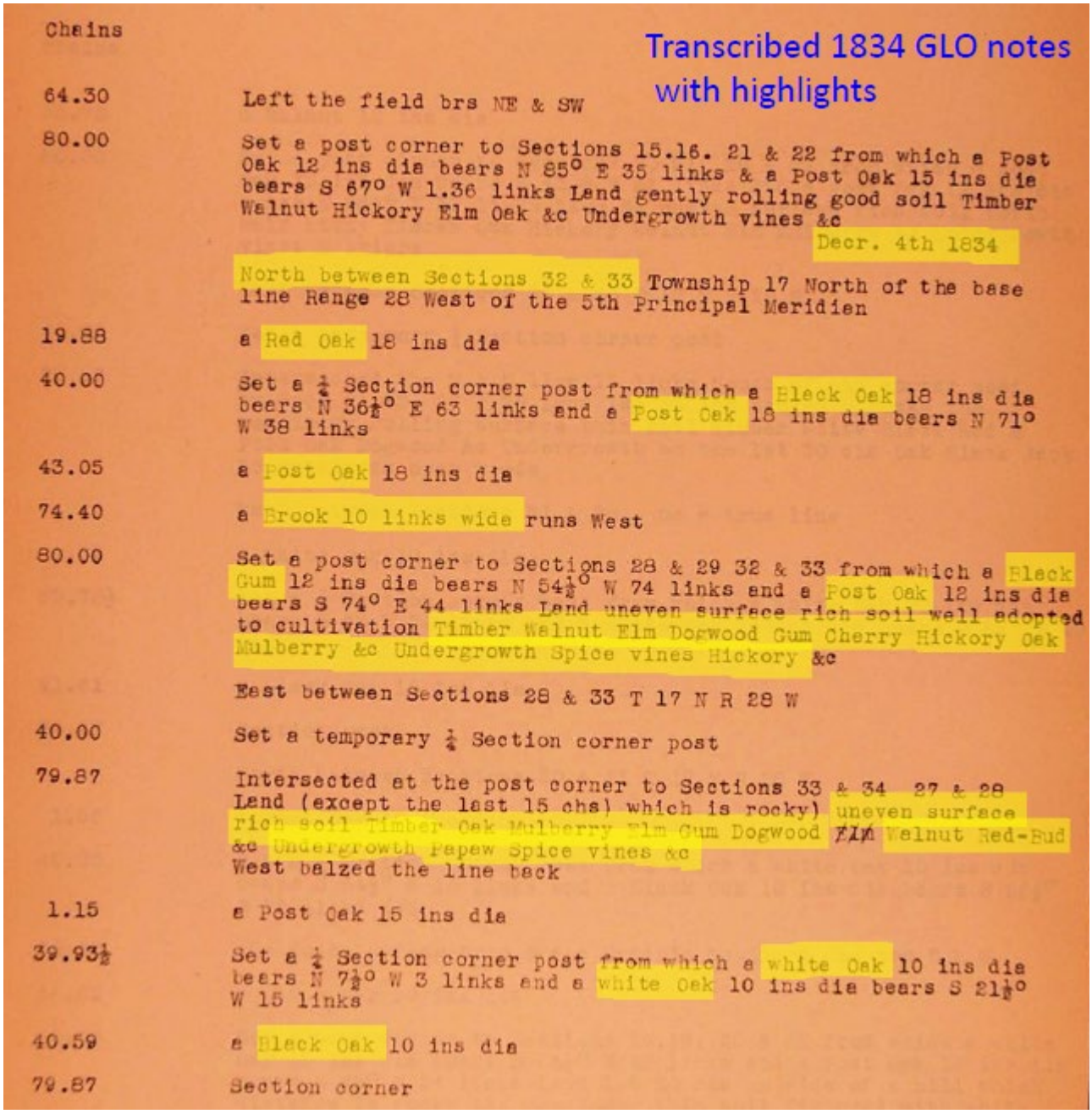
Government Land Office (GLO). On April 24th, 1820, John A. Neill received a land patent for, what would today be considered, the extreme western tip of Mill Branch Park along Highway 45 (E. Bowen Blvd.).

On December 4th, 1834, a GLO survey was completed on this site to establish the Public Land Survey System (PLSS). The PLSS imposes a multi-tier grid system of 6-mile-wide townships (north/south cells) and ranges (east/west cells), with 36 one-mile-square sections comprising each township. Natural features like timber stands, prairies, streams, and barrens, as well as developed features like farms, fields, and orchards, were documented as surveyors marked section corners and walked a series of 66-foot chains along each one-mile section boundary. The Arkansas Archaeological Survey's J.J Lockhart provided the notes for the 1834 survey along two sides of one section of Mill Branch Park, highlighting some items of interest (Fig. 4). The point of origin for this survey is the southern corner of sections 32 & 33 in the vicinity of 36.091736, -93.980490, roughly 425 feet due east of the merging of Tuttle Road and Wandering Way. The second segment of the survey traverses the boundary of Sections 32 & 33 heading north, with the third segment of the survey turning east along the boundary of Sections 28 & 33. Public land surveys were based on the statute mile, subdivided into chains and links, not feet and inches. A survey chain is 66 feet long, with 80 chains comprising a mile or the entire length of one section. Each chain is composed of 100 links, each of which is 7.92 inches in length. Length in chains can be converted to feet by multiplying the chain value by 66.

The notes pertinent to Mill Branch Park are below, entering the site around the 55th chain in the second series, between Chains 43.05 and 74.40 (Fig. 4).

> The survey note highlights at various chain lengths are as follows:
>
> 43.05 (36.099485, -93.980191) – "a post oak 18" inches in diameter." This is off-site to the south, now the southern edge of a pond.
>
> 74.40 (36.105208, -93.980010) – "a brook 10 links wide (~66 feet) runs west." This would be the main stream running through the site.
>
> 80.00 (36.106208, -93.980018) – "Set post corner to Sections 28 & 29, 32 & 33. . . a black gum 12" in diameter. . . and a post oak 12 inches in diameter. Land uneven surface, rich soil well adopted to cultivation. Timber walnut, elm, dogwood, gum, cherry, hickory, oak,

mulberry, & undergrowth spice vines hickory." From here, the survey turns due east, along the border of Sections 28 & 33.



Chains

Transcribed 1834 GLO notes with highlights

64.30 Left the field brs NE & SW

80.00 Set a post corner to Sections 15.16. 21 & 22 from which a Post Oak 12 ins dia bears N 85° E 35 links & a Post Oak 15 ins dia bears S 67° W 1.36 links Land gently rolling good soil Timber Walnut Hickory Elm Oak &c Undergrowth vines &c

Decr. 4th 1834

North between Sections 32 & 33 Township 17 North of the base line Renge 28 West of the 5th Principal Meridien

19.88 a Red Oak 18 ins dia

40.00 Set a ¼ Section corner post from which a Bleck Oak 18 ins dia bears N 36½° E 63 links and a Post Oak 18 ins dia bears N 71° W 38 links

43.05 a Post Oak 18 ins dia

74.40 a Brook 10 links wide runs West

80.00 Set a post corner to Sections 28 & 29 32 & 33 from which a Bleck Gum 12 ins dia bears N 54½° W 74 links and a Post Oak 12 ins dia bears S 74° E 44 links Land uneven surface rich soil well adopted to cultivation Timber Walnut Elm Dogwood Gum Cherry Hickory Oak Mulberry &c Undergrowth Spice vines Hickory &c

East between Sections 28 & 33 T 17 N R 28 W

40.00 Set a temporary ¼ Section corner post

79.87 Intersected at the post corner to Sections 33 & 34 27 & 28 Land (except the last 15 chs) which is rocky) uneven surface rich soil Timber Oak Mulberry Elm Gum Dogwood Ash Walnut Red-Bud &c Undergrowth Papew Spice vines &c West belzed the line back

1.15 a Post Oak 15 ins dia

39.93½ Set a ¼ Section corner post from which a white Oak 10 ins dia bears N 7½° W 3 links and a white Oak 10 ins dia bears S 21½° W 15 links

40.59 a Bleck Oak 10 ins dia

79.87 Section corner

Figure 4: General Land Office (GLO) survey notes for the 1834 survey along the west and north perimeter Section 33 in Township 17N, Range 28W. The boundaries for Mill Branch Park would begin approximately around the 55th chain in the second series and end somewhere before the 40-chain mark in the second series.

In July 1859, another 40 acres of the central one-third of Mill Branch Park (the NW ¼ of the NW ¼ of Section 33) was granted to Moses Dutton through a land patent. The adjoining 40 acres to the

west (the NE ¼ of the NE ¼ of Section 32) was granted to Moses and James Dutton through a second land patent issued October 1st, 1860.

In 1894 the Washington County Atlas was published by Gordon V. Skelton, documenting the site to be primarily cropland, with scattered trees in the southeast quadrant (Fig. 5). The land grant awarded to Moses Dutton is also noted in the western sections of Mill Branch Park. The atlas details parcel ownership at that time as well as indicates the site of the original road connecting the towns of Fayetteville to Huntsville (Fig. 5, 6). At various points in Mill Branch Park, the old roadbed is still faintly evident. The atlas also suggests much of this site has been in agricultural production, primarily row crops, orchards, and livestock fields, for several decades.

Often, sites which have been in cultivation for significant periods of time have reduced indigenous plant materials stored in the seed bank – efforts to re-establish indigenous plant communities will likely need heavy seeding to become established. Old roadbeds can be susceptible to erosion as they were often not laid down along topographic gradients but rather against the gradient. These paths can also have heavily compacted soil, complicating the establishment of some indigenous plant communities without first reducing the soil compaction through aeration or various means.

Aerial & Satellite Imagery

Comparing historical imagery of Mill Branch Park suggests relatively minor changes in land use or canopy coverage (Figs. 6-8). Some notable changes include:

- Creation of two livestock ponds in the southern half of the site.
- An established pathway once existed in the western pasture on the north side of the main stream, possibly covered in gravel at some point, leading to a corral constructed on the north side of the stream in the northwest corner.
- Removal of an unidentified structure north of the stream in the northwest section and construction of a barn just a short distance north of it.
- A farmhouse possibly stood in the 1941 image, perhaps replaced with the poultry shed.
- Clearing of the riparian area north of the stream in the northeast corner.
- Conversion of row crops and removal of an unidentified structure, presumably a barn, in the southwest field.
- Increase in canopy density in the southern half of the site.
- Conversion of open ground into successional foliage in the northeast corner along the stream and atop the ridge to the south.
- Construction of an enclosure in the southeast pasture.

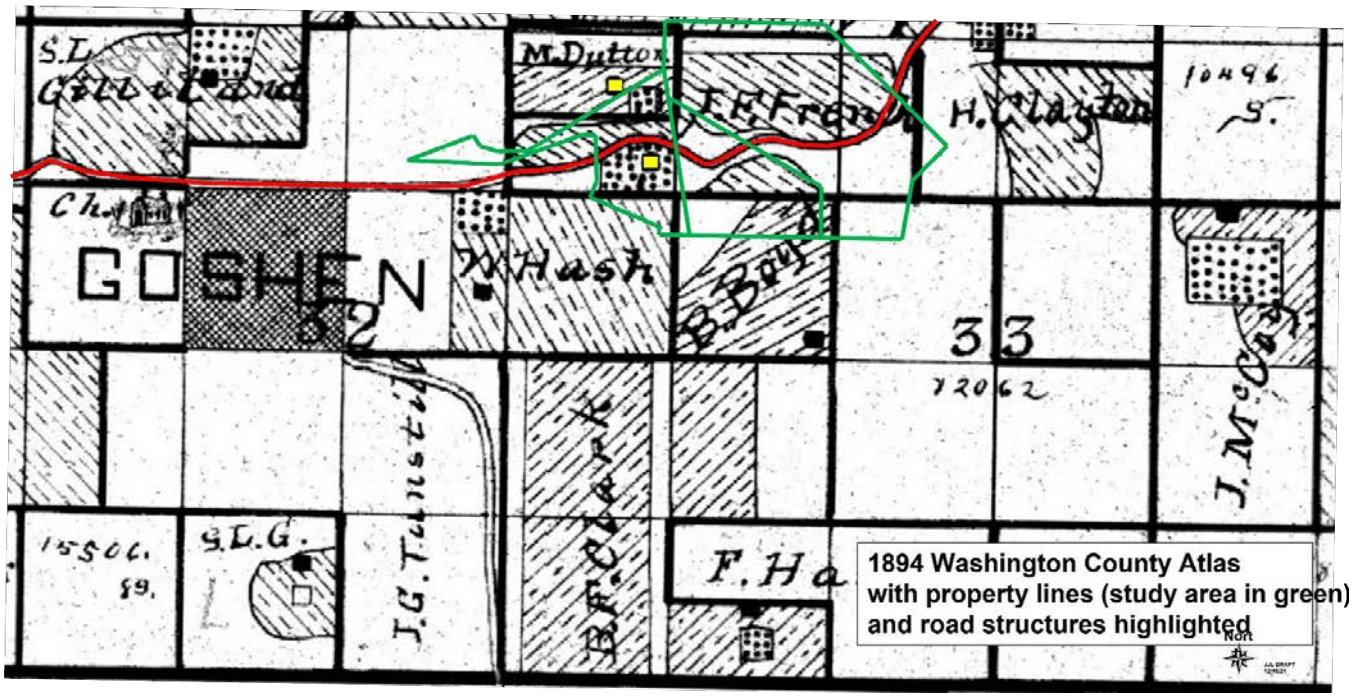


Figure 5: The 1894 Washington County Atlas, showing property lines, row crops, orchards, and existing infrastructure. The boundaries of Mill Branch Park (green), nearby structures (yellow), and the road from Fayetteville to Huntsville (red) are superimposed.

Figure 6: 1941 aerial photo with Mill Branch Park property lines, 1894 road, and livestock corral (top yellow square) superimposed. Provided by the Arkansas Archaeological Survey. Original photo source: USDA.

Figure 7: Images 1-3 of ortho-corrected aerial imagery from Google Earth, various dates (1994-2008).

Existing Infrastructure, Pathways, & Fences

Any existing structures, pathways, and fence lines were noted during site visits, though fences were largely casually recorded (Fig. 8). The primary access road into Mill Branch Park is across from Paul Pray Drive. It was initially dirt but was reinforced with gravel in 2021. This new access parallels and crosses the main stream bisecting the property as it leads to the western portion of Mill Branch Park. This road goes through an ecologically sensitive location with at least one tracked plant species present, pale jewelweed (*Impatiens pallida*), as well as being an ideal habitat for numerous charismatic spring wildflowers along the streambank and opposite hillside (Fig. 9).

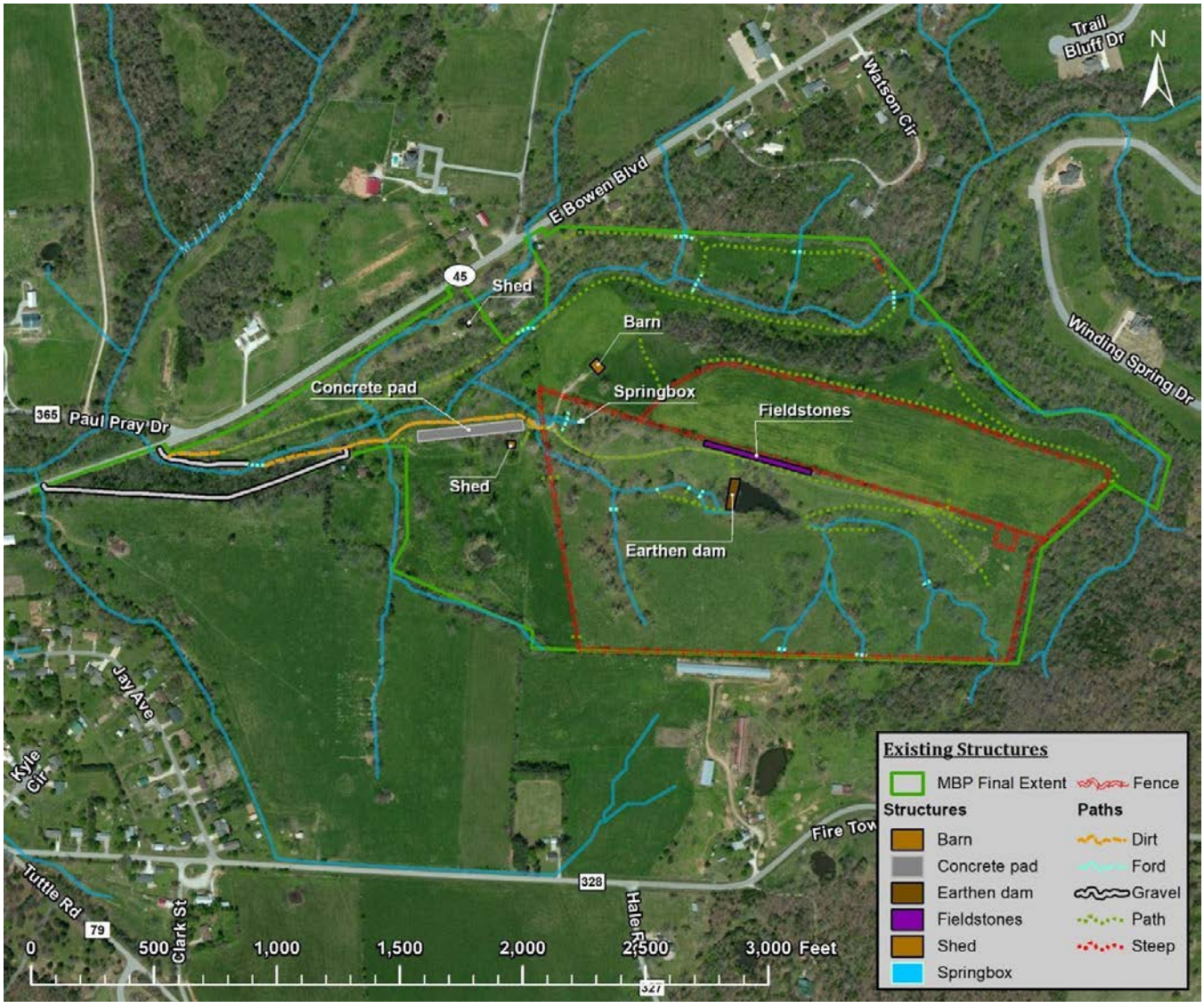


Figure 8: Identifiable existing structures, pathways, fence lines, and drainages superimposed over ortho-corrected aerial imagery. The fences layer does not include all fence lines likely present, only those noted during site visits.

Figure 9: (Left): Pale jewelweed (Impatiens pallida) observed at Mill Branch Park. Photo by Nate Weston. 2021-07-29. (Right): A robust colony of pale jewelweed along a healthy riparian zone near Avoca. Photo by Nate Weston. 2019-08-06.

A well-established dirt road, degrading to a path, bisects the entire tract, running E/W and paralleling the demolished poultry house to the north. The path runs east, skirting alongside the north side of the large pond until it gradually vanishes around a small livestock enclosure on the east edge of the property, around 36.102979, -93.973499. This path suggests good access to the majority of Mill Branch Park and could be improved and connected with other pathways to create a circuit around the northern half of Mill Branch Park. A small spur comes off this path, roughly 110ft. NE of the poultry house around 36.1044531, -93.979661, fording a small stream originating at a large spring box approximately 70ft. to the E of the path.

Entering Mill Branch Park from the road southeast of Paul Pray Dr., a path branches off 40ft. after exiting E. Bowen Blvd. and just before the ford across the main stream. This path goes east through the pasture and parallels the main stream before crossing around 36.105050, -93.980257. This site shows significant erosion along the streamsides due to cattle accessing the stream but offers potential for access via foot traffic. Across from this second fording, a faint path follows the N perimeter of the NW pasture until coming to the third ford around 36.105698, -93.977763. From here, the trail may continue E/W along the bottom of the ridgeline, but if so, it is not able to become well established due to frequent flooding here. N of the ford, the path goes to the N edge of the

pasture, coming to a "T" with one path going W towards E Bowen Blvd. and the other going E, eventually representing the fourth ford along the main stream, with the path itself going up the ridgeline at a sharp angle. This segment is difficult to navigate due to having been abandoned as a pasture ca. 2008-2009 – various brambles and other early successional and opportunistic plant species form the dominant coverage here. This path also overlooks another drainage to the NE, separating Mill Branch Park from the Knolls subdivision. The drainage itself originates from the subdivision, with a steep slope going down to the drainage below the path. The path itself gradually reaches the NE corner of a fenced pasture around 36.103612, -93.972102.

Other minor pathways exist, such as a short path branching off just E of the poultry house, going south and gradually disappearing somewhere east of the small pond in the SW corner. The packed-earth dam along the west side of the largest pond also forms something of a short path connecting the path to the north with the pasture to the south. Throughout the park, various animal trails, primarily created by cattle, can also be found crossing various drainages and forested slopes. As of October 2021, cattle had been completely removed from the property.

Infrastructure such as trails should avoid sensitive habitats like seeps, springs, and rock outcrops. A minimum buffer of 50 feet is recommended between infrastructure and ecologically sensitive zones to reduce disturbance to wildlife and ecological degradation. Streams significantly benefit from broader buffer zones, as they require floodplain access to disperse excess stormwater and maintain appropriate sinuosity. These values are obtained from the University of Arkansas' Division of Agriculture document "Nature Trail Development on Small Acreages" and are based on wildlife flight responses to species often found in the Ozarks. Best management practices to reduce erosion should be implemented at locations where construction below this buffer is unavoidable. Trails crossing spring runs and small streams should be on elevated bridges with warning signs to discourage activities associated with soil disturbance, such as biking on soft-surface trails after recent rain. The stacking of rocks should be discouraged to avoid disturbing wildlife and increasing soil erosion susceptibility. Routine trail maintenance should include survey and removal of invasive species, which often spread along trail corridors. Once established, invasive species can be challenging to remove. Invasive understory shrubbery can quickly dominate trailsides, blocking viewsheds, reducing the aesthetic appeal of the trails, and creating an ecological nightmare (Fig. 10).

Figure 10: Dense stands of bush honeysuckle, an invasive understory shrub common throughout urban areas in Northwest Arkansas, infest the trailsides along the Razorback Greenway. Invasive understory shrubs like these can obstruct viewsheds of natural features and foster a sense of unease among trail users, who can't see what's around them. Removal of invasive understory shrubs from the park and routine spot-treatment can improve the visibility and aesthetic appeal of trails as well as restore ecological function. Photo by Nate Weston, 2018-10-18.

Surrounding Area Context

Mill Branch and Richland Creek merge just west of Mill Branch Park, themselves merging with the White River a short way downstream in the area known as "Twin Bridges." The areas around Mill Branch Park are primarily pastureland to the south and dense forest to the north (Fig. 11). Houses dot the border of Mill Branch Park to the west, while The Knolls subdivision, a low-density residential community, lay across a steep slope and densely forested drainage basin immediately to the east of Mill Branch Park. Benson Mountain is just 1.5 miles to the east, with Mill Branch Park

being situated on its westward slopes. Gilliam Mountain is roughly 1.0 miles to the southwest, with approximately 0.5 miles of pasture between its slopes and the SW extent of the park. The majority of surface water originates from seeps and springs emerging from groundwater underneath Benson Mountain. While several large poultry house operations are situated on Benson Mountain, runoff from the southern half of Benson Mountain drains south and eastward into Dry Creek. Another unnamed hill to the north feeds Mill Branch itself, though the waters do not flow through Mill Branch Park.

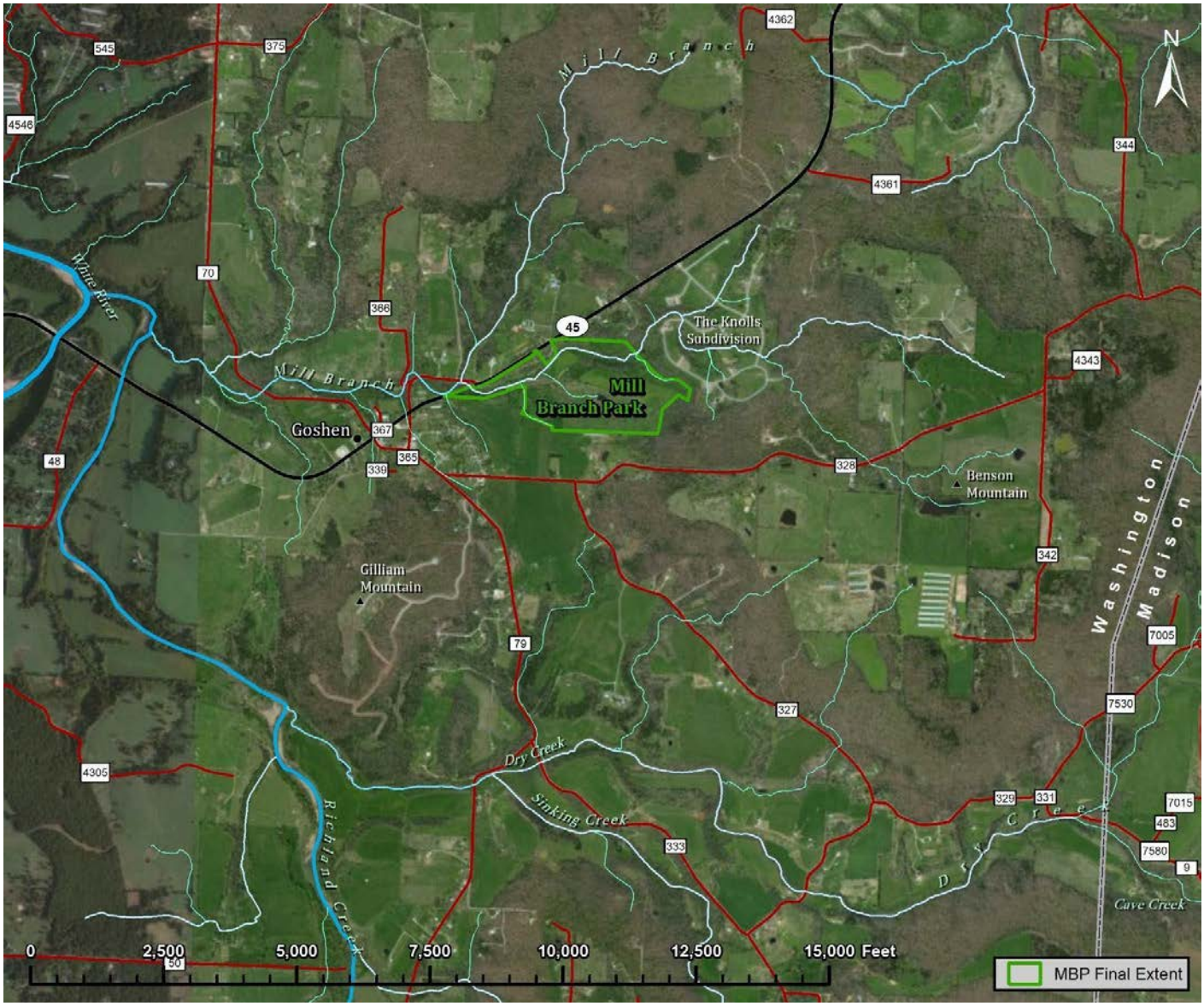


Figure 11: The extent of Mill Branch Park in the context of its surrounding region. Nearby hills, rivers, road networks, and neighborhoods all influence the ecology and natural features of Mill Branch Park.

Elevation, Topography, Soils, & Geology

(With contributions by J.J. Lockhart)

Elevation

Mill Branch Park is roughly 1,250 feet above mean sea level, situated on the northern slope of a ridgeline extending west from nearby Benson Mountain to the southeast (Fig. 12, 13). The ridgeline above and to the south of Mill Branch Park is roughly 1,500 feet in elevation, while the river bottom in the center of the site is approximately 1,170 feet, heavily influencing Mill Branch Park's topography and drainage networks. This 330-foot elevation difference causes sheet rain to rapidly roll off the ridgeline above and into the upland drainages in the southeast portion of the park before collecting in the large pond below. Other waters seep into the valley from groundwater and surface runoff from the narrow gap to the northeast, between Benson Mountain and the unnamed hill to the north, as well as from sheet runoff collecting on the north side of E. Bowen Blvd.

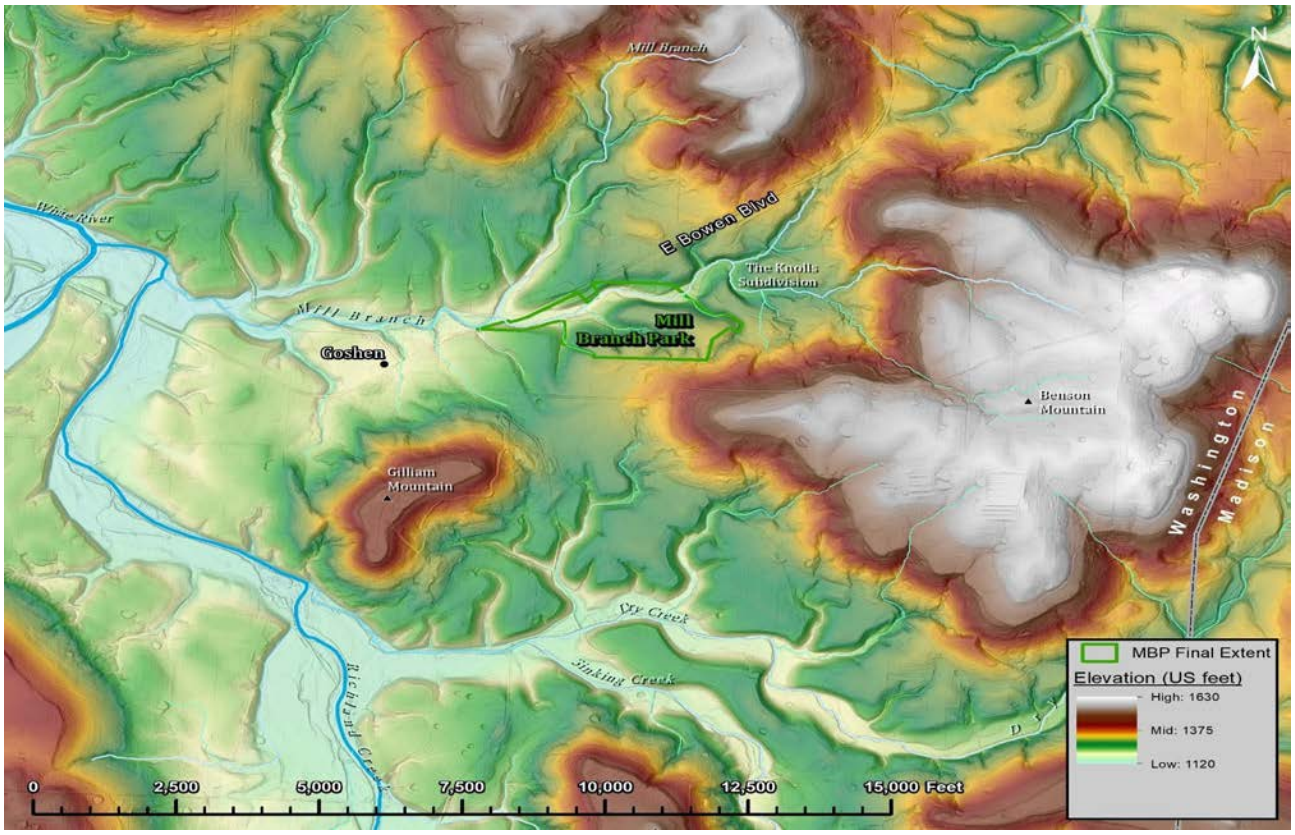


Figure 12: A shaded relief map of Mill Branch Park and the surrounding region. The site's elevation and topography are heavily influenced by its rapid change in elevation and its position along the ridgeline extending west of Benson Mountain.

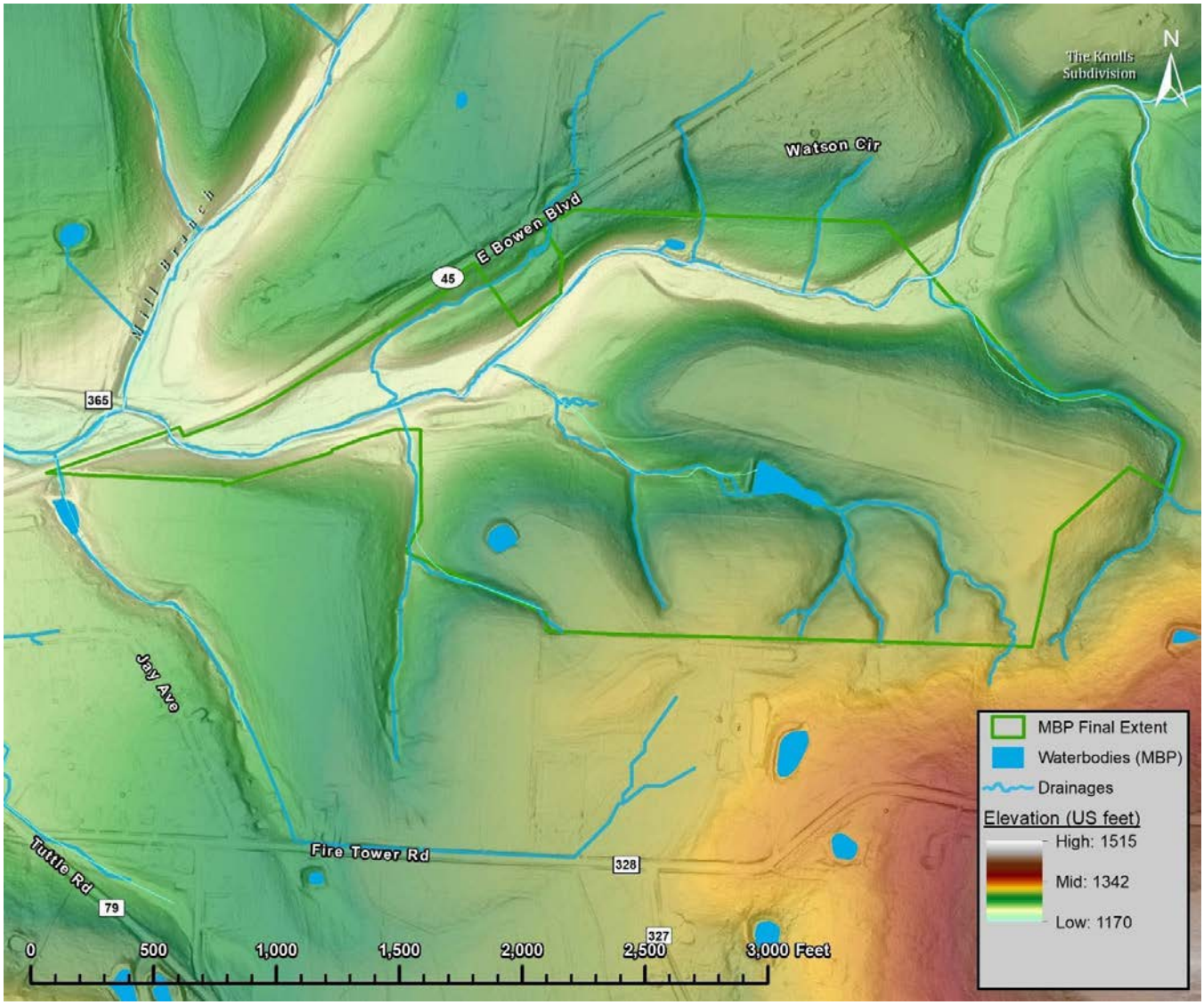


Figure 13: A shaded relief map of Mill Branch Park with drainages systems included. The site's elevation and topography are heavily influenced by its rapid change in elevation and its position along the ridgeline extending west of Benson Mountain.

Topography

Mill Branch Park's topography is primarily defined by its being situated on the western slopes of Benson Mountain and the northern section of a ridge running E/W. The extreme north edge of Mill Branch Park is part of a different slope to the north, but the ridgeline of Benson Mountain and the drainage basin created by Mill Branch itself heavily define Mill Branch Park's topography and the steep slopes. Mill Branch Park is sloped downhill from SE to NW, with roughly 330ft. of elevation change from the southern edge of Mill Branch Park to the riverbed of the primary streambed. The

majority of Mill Branch Park's slopes are walkable, with 50.5% of the site's slopes being less than 8.5 degrees and 44.7% of the site having slopes between 8.5 and 24 degrees (Fig. 14). Only 4.7% of the site has slopes greater than 24 degrees, these being primarily between the southern access road off E. Bowen Blvd. and the main stream flowing through the property, the northern section of the park between the stream and E. Bowen Blvd., the ridgeline between the stream and the east-central pasture, around the drainages in the southern half of Mill Branch Park, and below the path above the drainage separating Mill Branch Park from The Knolls subdivision.

Trail design should prioritize adhering to the site's natural topographical contours whenever possible. Paths and trails should intersect slopes at a sharp angle, preferably less than 30 degrees with respect to the contour, to prevent rill and gully erosion. Water paralleling linear features like roads and trails can concentrate stormwater and rapidly erode exposed soil, endangering the road or trail and potentially causing injury. Stormwater dispersal features such as runoff bars should be included in all linear feature designs to prevent stormwater from channeling on one side of the trail.

The various ridgelines, slopes, grades, and structural features like roads, pathways, and the large earthen dam can also be neatly seen using a multidirectional hillshade model (Fig. 15). A slight depression area just north of the stream in the north-central section of the park. It's unclear if this depression is a natural feature, such as a sinkhole or if it was excavated from the slope above the stream.

Figure 14: Slope map of Mill Branch Park. Slopes greater than 10 degrees are considered undesirable for casual walking, and all paths should ascend slopes at an angle to avoid gully formation.

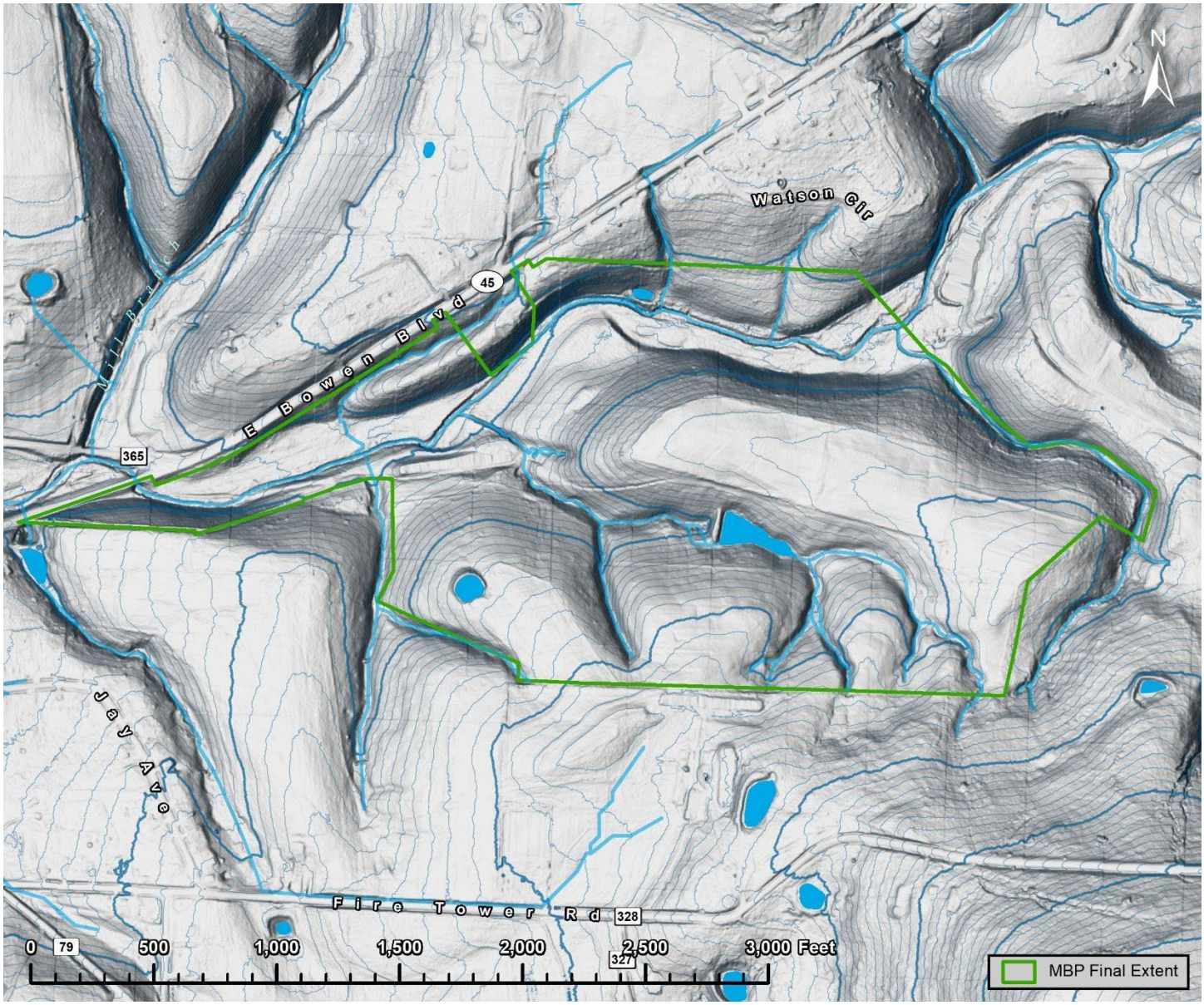


Figure 15: Multidirectional hillshade model (1M resolution) of Mill Branch Park. Roadbeds, pathways, ponds, boulder clusters, and structural footprints are readily apparent.

Soils

The soils of Mill Branch Park are largely gravel-heavy but fertile, soils deposited from millennia of weathering. The upper slopes show less weathering and retain much more organic material (Fig. 16). The potential for prairie restoration is significant here, but the two soil types have different moisture regimes. Gravelly soils tend to be very porous, with nutrient-rich and water-holding organic matter wedged between the small stones; their water tables tend to be lower as they

conduct water very rapidly. Silt-loam soils, on the other hand, tend to have higher organic matter, better retain moisture, and dry out slower. Both can support an abundant, rich assortment of vegetation, but drought-tolerant species with aggressive taproots will favor the gravely soils, whereas faster-growing species with fibrous root systems will favor the silt-loam soils. The band of Allen loam in the eastern section of Mill Branch Park would be ideal for a botanically rich upland prairie of grasses and wildflowers, while the gravelly soils below would be well suited to hosting native grasses, deep-rooted prairie sunflowers, milkweeds, and xeric species like *Baptisia*.

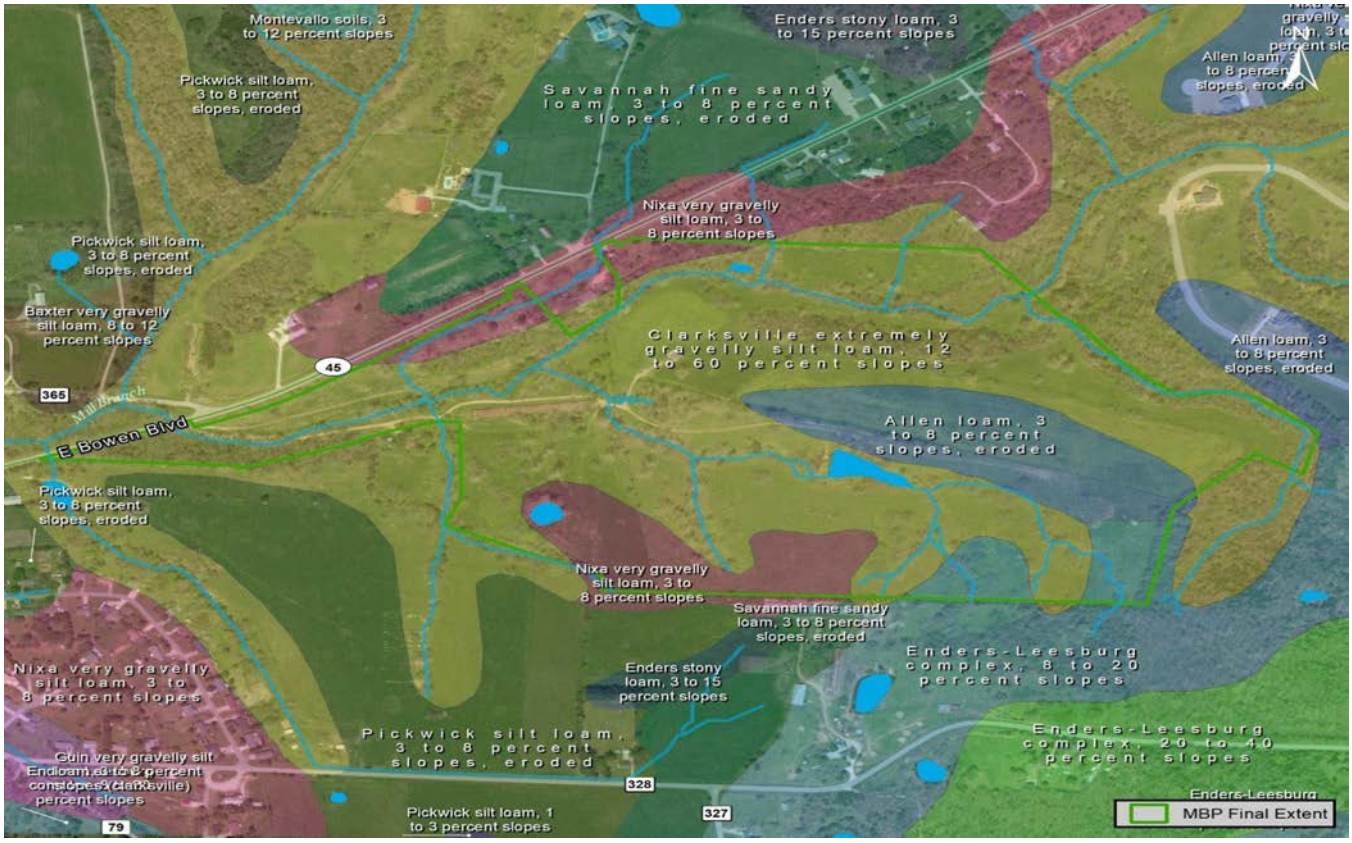


Figure 16: Soil features of Mill Branch Park. Gravelly soils (red and yellow) are very permeable, tending to be great at filtering stormwater and recharging groundwater but also prone to drying out quickly and favoring drought-tolerant plant species. More fertile silt-loam soils (blue, green) tend to recharge groundwater more slowly but also support more vegetation due to their sponge-like ability to hold moisture.

Geology

The parent materials of Mill Branch Park are sedimentary limestone, chert, sandstone, and shale formations created during the early-to-middle Mississippian geologic periods (Fig. 17). The NW edge of Mill Branch Park is defined by the Boone Limestone formation, a limestone/chert mix formed during the Meramecian (335-340 MYA) and Osagean (345-350 MYA) geologic periods. The southern portion of Mill Branch Park is a combination of the Pitkin Limestone, Fayetteville Shale, and Batesville Sandstone formations formed during various periods in the Mississippian. Limestone and chert tend to yield alkaline soils (pH >7), while sandstone and shale tend to yield slightly acidic soils (pH <7). Marine fossils, such as bryozoans, brachiopods, and crinoids, also tend to be present to varying degrees in these formations.

Figure 17: Geological formations of Mill Branch Park. Limestone/chert tend to yield higher pH than sandstone/shale, with plant communities reflecting that difference.

Surface Hydrology

(With contributions by Erin Scott)

Streams, Drainages, & Water Bodies

Mill Branch Park has several distinct drainages and at least three perennial surface water bodies (Fig. 18). The largest drainage, a perennial stream flowing NE-SW in the northern half, bisects the park into north and south. Three smaller perennial streams flow from the ridgeline in the southeast, meeting the primary stream with other, smaller streams in the northwest and southern sections. Each of these streams eventually tribute to the primary stream, merging and joining Mill Branch shortly after exiting the west side of the park. Other drainages exist, though these are intermittent and only flow during rain events. For the sake of clarity, the drainages in this management plan are named with respect to their headwater rank (e.g., the primary, second-order stream is referred to as "A," with successive streams referred to as "B," "C," "D," etc. with respect to the order in which they tribute to the primary stream "A." There are also at least three perennially inundated water bodies at Mill Branch Park, named with respect to their size in acres. A 0.6-acre (#1) pond is located in zone 6, a 0.2-acre pond (#2) in zone 5, and a small 0.1-acre pond (#3) is located in zone 3. The two largest ponds were likely created as agricultural ponds. It's unclear whether the third pond is a natural or manufactured feature. Detailed descriptions of these features are below.

A: Perennial stream with a drainage area of 1,131 acres, the primary drainage of Mill Branch Park. Tributes to Mill Branch 215 feet after exiting Mill Branch Park from the west side, merging with Richland Creek around the "Twin Bridges." The streambed shows moderate indicators of disturbance related to cattle. Some sections have severe incisions - these spots should be given extra attention and provided more buffer space as they will likely continue to degrade, expanding the streambed outward another 15-20ft until the stream reaches equilibrium and stabilizes.

B: Perennial stream with a drainage area of 42.2 acres, flowing along the east side of zone 9. The western sides show light disturbance from cattle. It has not been fully explored due to its relative remoteness. It tributes to "A" near 36.105663, -93.974885.

C: Intermittent drainage enters Mill Branch Park around 36.106268, -93.976371, bisects zone 8 with a drainage area of approximately 6.7a acres, tributing to “A” near 36.105461, -93.976432.

D: Intermittent drainage of 2.2 acres, fed by roadside runoff along E. Bowen Blvd. and entering the north side Mill Branch Park through zone 3 near 36.106297, -93.977973. Tributes to “A” near 36.105792, -93.978076.

E, F, G, H, and I: Intermittent drainages with a network of 12.2 acres flowing through zones 4 and 6. The lower reaches of E show significant incision erosion from cattle. Tributes to “A” somewhere near 36.105879, -93.978890.

J: Spring-fed intermittent stream originating from within a spring box in the vicinity of 36.104164, -93.979384. Mike Slay with The Nature Conservancy did a brief survey of this spring in September 2021. Flows west and tributes to “E” somewhere near 36.104219, -93.979956.

K: Perennial stream with a drainage area of 30.7 acres flowing around the southwestern portion of Mill Branch Park and zone 5, the streambed frequently diverging from Mill Branch Park’s boundaries and into adjacent properties. This drainage appears to turn back into Mill Branch Park somewhere between zones 1 and 4, but a permanent streambed is not evident in this area – it may have been covered or otherwise diverted overground or underground somewhere upstream. It appears to tribute to “A” near 36.104010, -93.982353.

L: Intermittent drainage of 3.6 acres from ditches along E. Bowen Blvd., entering Mill Branch Park around 36.106240, -93.980125 and bisecting zone 2. Possibly tributes to “A” near 36.104079, -93.982286.

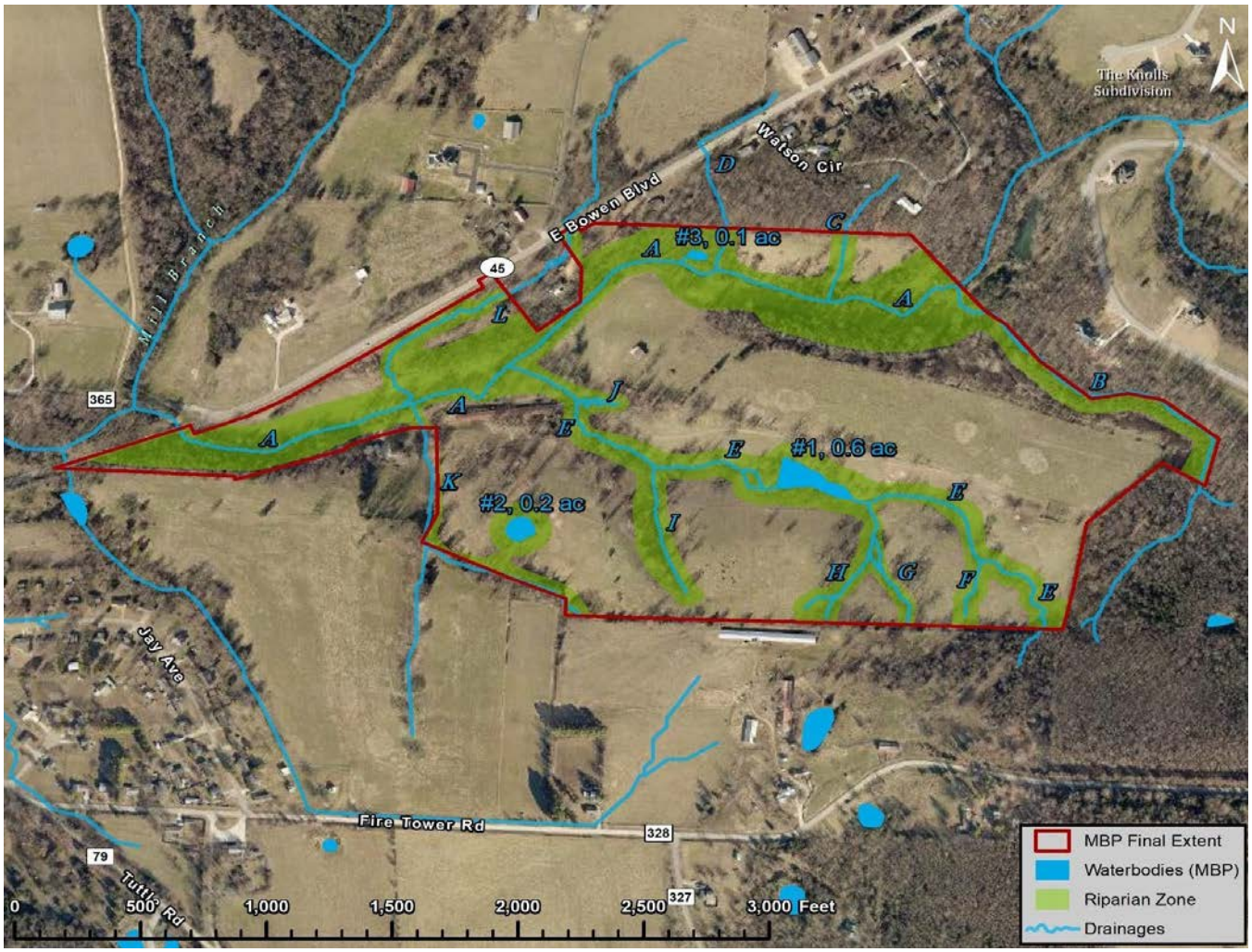


Figure 18: Drainages and waterbodies of Mill Branch Park. Drainages labeled with respect to their headwater hierarchy; ponds labeled with respect to their surface area, in acres.

Hydrology Impacts

Mill Branch Park is characterized by steep slopes, heavy disturbance from cattle, and excessive nutrient loading (or "eutrophication") of its surface water features. Duckweed and watermeal blanketed the entire surface of both ponds during site visits in July and September 2021. These factors significantly reduce water quality as well as quantity and have gradually converted Mill Branch Park's naturally diverse and stable streams and drainages into structurally homogenized and unstable intermittent streams, lowering the groundwater level, significant loss of riparian biomass, widening and increased "flashiness" of streams during rain events, and an overall reduction in water quality and water storage.

The most significant factor impacting Mill Branch Park's surface water quality is long-term intensive cattle grazing. Rill and gully erosion, vegetation and canopy reduction, eutrophication of waterways, and eutrophication of surface waters are indicators of disturbance associated with long-term, intensive cattle grazing. Regular grazing and trammeling by livestock destabilize vegetation and create erosion hotspots, especially when their pathways intersect drainages. Rills form and become gullies with successive traffic, while "loafing" inside the streambed encourages the formation of headcuts and subsequent incision of streambanks. These headcuts migrate upstream, "unzipping" the landscape as the riverbed widens and the surrounding land erodes to the newly imposed elevation. Whereas periodically intense grazing encourages root production by native grass species, sustained intensive grazing prevents plants' recovery and facilitates the transition of native grasslands to pastures of short, weedy species growing atop unhealthy and dehydrated soil with low organic matter and greatly diminished ability to cycle stormwater and nutrients from the landscape. Intense, sustained livestock grazing inputs tremendous nutrient loads into the ecosystem through their urine and feces, which is carried into streams and rivers through sheet runoff, creating eutrophic conditions. These nutrient-overloaded waterways lead to explosions in aquatic vegetation like duckweed, watermeal, and algae which eventually die off. Unfortunately, the decomposition of this vegetation consumes dissolved oxygen in the water, potentially leading to large die-offs of other organisms like fish and macroinvertebrates (Turnage, 2018). Decades' worth of these nutrient inputs also creates "legacy" nutrients which remain in the soil, gradually leaching into streams and stockpiling in pond sediments, affecting water quality long after cattle have been completely removed from the landscape. Ponds which have become eutrophic can take many years before their nutrient levels fall to levels capable of supporting a healthy ecology.

Riparian Zones

Preventing nutrients from entering surface waters through runoff is perhaps one of the most effective management practices to protect water quality. Riparian buffers along the entire perimeter of surface water bodies intercept nutrients before reaching the water, stabilize streamsides, and provide vital wildlife habitat (Cunningham, Stuhlinger, & Liechty, 2009). Riparian area composition and width are highly situational and should adapt to the site's context and

management needs. Riparian areas are often divided into zones based on their human-designated purpose, such as organic input, soil stabilization, water quality, or habitat (Hawes, 2005).

Standard riparian area designs are variable, fixed, and three-zone – variable buffers factor variables like slope, imperviousness, and erodability to determine the width. Fixed-width buffers impose an arbitrary value (e.g., 50, 100, or 150 feet) for the width. Three-zone buffers (Fig. 19) have become quite popular – they create specialized zones within the buffer to maximize the buffer's efficiency and value while reducing maintenance costs. A hypothetical three-zone buffer would include Streamside, Middle, and Outer zones. The Streamside zone would be 15 feet wide, consisting of water-loving and aggressively rooting trees and shrubs to stabilize the banks and provide shade, and should only be managed for removal of nuisance vegetation. The Middle zone would be 60 feet wide and consist of a mix of water-tolerant trees and patches of thicket-forming shrubs, carpets of grasses underneath to intercept nutrients, slow floodwaters, provide habitat, and should only be managed for occasional thinning to maintain vigorous growth. The third zone would be 30 feet wide and consist of a rich mix of sun-loving grasses and wildflowers blooming throughout the growing season to slow surface runoff, intercept nutrients, provide pollinator and bird habitat. Maintenance of this zone should only require occasional mowing, once in late summer, with the mower's blade at least 8 inches off the ground to avoid cutting slow-growing species. Never mow right to the streamside to prevent destabilizing the streambanks. Though not always included, any buffer should consist of an Aquatic zone, the zone immediately adjacent to the stream and should consist of water-loving or "hydrophytic" plant species, often classified as "facultative-wetland" or "obligate-wetland" by the US Army Corps of Engineers' Wetland Indicator Status through its National Wetland Plant List. This zone should be, at minimum, 5 feet wide for ponds. For streams, this area should be as wide on either side as the stream itself (e.g., a 10-foot-wide stream should have a 10-foot-wide buffer on both sides) to ensure adequate bank stability and wildlife habitat. The area above this should contain mostly shrubs and fewer trees, with grasses and forbs underneath. This zone should be 50-60 feet wide to provide a healthy amount of shade, habitat, and intercept runoff. The outermost area should consist of a mix of scattered trees and shrubs but should be dominated by grasses and forbs. This zone should be 40-50 feet wide to ensure runoff interception, safety for wildlife sheltering within the middle zone, pollinator habitat, and visibility for people walking along trails.

Riparian areas with a "rough" look are perfectly fine and natural-looking (Fig. 20). Only species indigenous to the Ozarks should be incorporated in any planting, preferably local-ecotype species (plants with genetic stock originating from the Ozarks ecoregion). Buffer width should increase in response to environmental variables like slope, erodability, and traffic (Hawes, 2006) and should incorporate visible designated access lanes to points of interest inside the riparian area, such as the large pond and perennial streams. Clearly designated and visibly marked access points will discourage the creation of "rogue" trails, which can destabilize the riparian area, reduce visual appeal, and decrease the buffer's effectiveness.

Peak Flow & Base Flow

Converting stormwater peak flows into base flows or "flattening the curve" increases the power of riparian areas exponentially. Identify stormwater transport, storage, and processing zones along streams and drainages to reduce the erosive power of peak flow and increase the hydrating power of base flow. Designating floodplain storage zones, even on small drainages, gives stormwater space to be rest during storm events, encouraging it to slow and be absorbed by the surrounding soil, thereby taking it "out of the equation" for erosion and flooding while recharging groundwater and hydrating the landscape.

Avoid strategies meant to accelerate conveyance of water off-site, especially those using impermeable features – due to capillary action, fast-flowing water actively draws moisture from the streambed, dehydrating the landscape while escalating the erosive force of water moving downstream. Dehydrated soil also resists absorbing water during rain events, exacerbating the problem of erosion and flooding. Spread it out and slow it down with semi-permeable structures instead.

Making a Plan

Developing a management plan with ongoing water-quality monitoring for parameters like nutrients, bacteria, dissolved oxygen, pH, and minerals can help identify a baseline for improvement, identity patterns, challenges, opportunities, and create a pathway to managing

existing and legacy water quality and water quantity resources at Mill Branch Park. This plan should evaluate the current conditions of the waterbody and its drainage area and consider the intended use(s) of the drainage, stream, or waterbody to ensure these surface-water systems meet the intended needs of Mill Branch Park.

Phosphorus, a limiting agent for aquatic vegetation growth, can be reduced in ponds through treatment with a flocculant agent such as aluminum sulfate or lanthanum, both of which bind to phosphate to create biologically inert, insoluble compounds which settle to the bottom. Certain herbicides such as flumioxazin may be used (Turnage, 2018), but any herbicide used should not contain a surfactant, which can be fatal to many amphibians and beneficial aquatic insects. Repeated skimming and removal of aquatic vegetation can also gradually reduce nutrients and vegetation to stable levels.

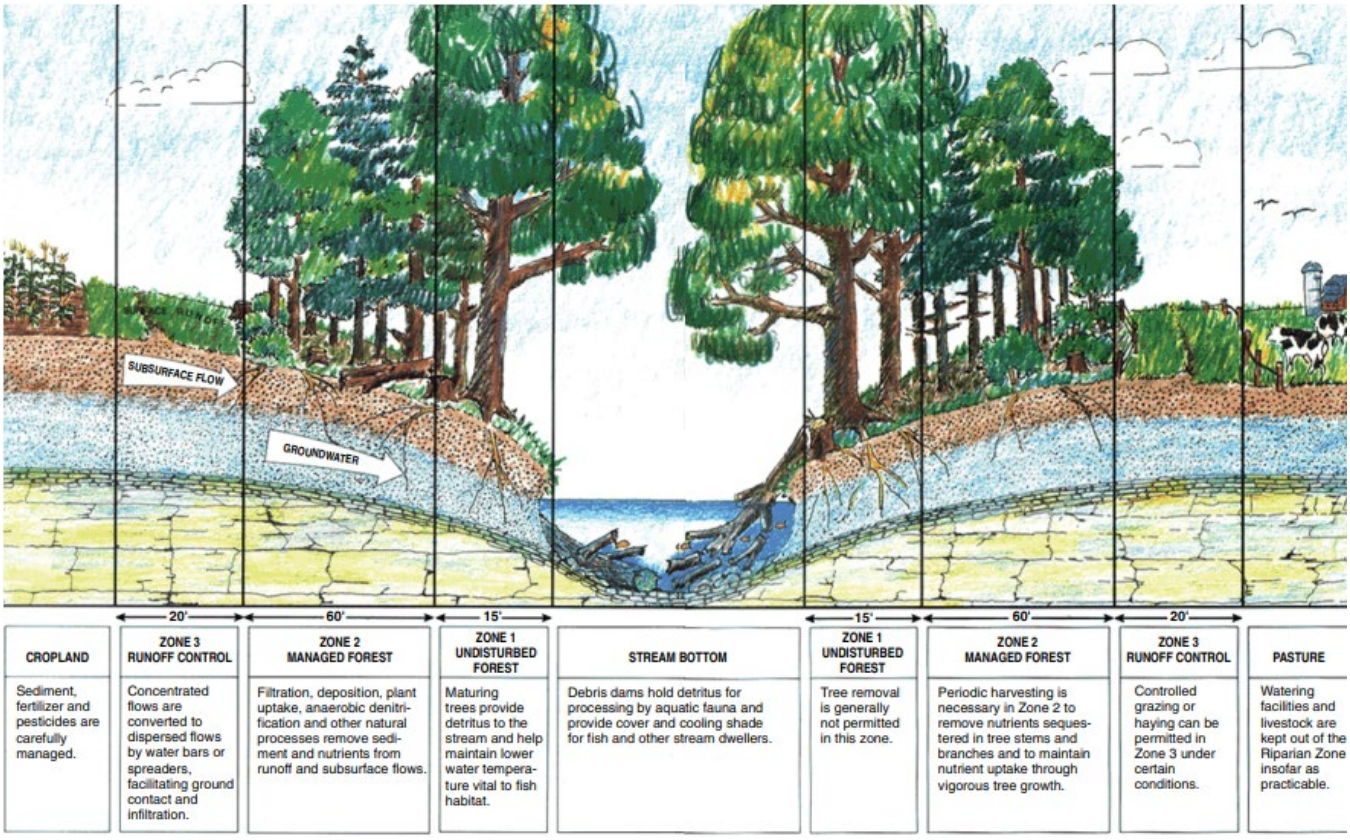


Figure 19: Example three-zone riparian buffer with streamside, middle, and outer zones. All zones should include only native species appropriately selected for the zone's moisture availability. Not included is an Aquatic zone immediately beside the stream, which should incorporate sedges, rushes, and other hydro-phytic or "water-loving" species (Cunningham, Stuhlinger, & Liechty, 2009).

Figure 20: Healthy riparian areas should incorporate a diverse mix of water-loving grasses like rushes and sedges, forbs like bluestar and cardinal flower, aggressively rooting shrubs like Carolina willow, Chickasaw plum, Viburnum, ninebark, elderberry, spicebush, buttonbush, vernal witch-hazel, deciduous holly, American hazelnut, and shrubby St. John's wort underneath shade-producing trees like river birch, black willow, basswood, sycamore, Source: Mini-guide to Types of Riparian Buffers, James River Association.

Quick reference recommendations:

Develop a water-management plan to reduce ongoing and legacy nutrient loading into waterways. Designate access points for streams, ponds, and other points of interest. Prevent nutrient loading by establishing and maintaining adequate riparian buffers along all waterways. Remove nuisance aquatic plants and decrease available phosphorus. Designate stormwater transport, storage, and treatment zones along all waterways. Decrease peak flow by installing semi-permeable barriers along drainages. Develop long-term water-quality monitoring.

Ecology

(With contributions by Hugh Lumpkin and Brooks Wilhoite)

Ecoregional Influences

Mill Branch Park is part of the Lower Boston Mountains ecoregion (38b), part of the Boston Mountains, and the greater Ozark Plateau. According to Section 3, "Ecoregions of Arkansas" within the Arkansas Wildlife Action Plan, the Lower Boston Mountains ecoregion is described as "a mosaic of woodland, forest, and savanna that contrasts with the denser, more moist and closed forests of the Upper Boston Mountains (38a). Potential natural vegetation is oak-hickory–pine and oak-hickory forests. . . Both precipitation and forest density decrease toward the west, where oak-pine woodland or savanna become common." The canopy of Mill Branch Park is predominantly a mix of oak and hickory in the upland sections with sycamore, boxelder, and hackberry along the drainages. Though much of the land here has been managed as cattle pasture for several decades, with most of the open pastures being dominated by pasture grasses like fescue and Johnsongrass, Mill Branch Park still enjoys a diverse assemblage of species representative of the Lower Boston Mountains. Many locations in the Lower Boston Mountains are a mosaic of open woodlands and mesic (medium moisture) forests, possessing varying, subtle changes in slope, aspect, and geology. Any management activities, particularly the application of prescribed fire, should be based on local site conditions and adaptive to the response of the ecosystem to management actions.

Ecological Restoration and Management

Structural complexity, the diversity in structures such as trees, shrubs, grasses, even inorganic features like rocks, increase the ecological niches available to wildlife whether on the ground, overhead, or in streambeds. Increasing structural diversity has a cascading and positive impact on the diversity of habitats and species, especially for specialist species. Structural/niche diversity also increases the site's resistance and resilience to disturbance, both internal and external. As a rule, all management efforts should prioritize the increase of structural complexity.

It should be noted Mill Branch Park is a novel ecosystem characterized by anthropogenic (human-driven) disturbance regimes (e.g., fire suppression and intensive herbivory by whitetail deer) and

by moderate, development-driven isolation from its historic landscape. Restoration of novel ecosystems is recommended to be defined by actions meant to assist the recovery of an ecosystem, which has been degraded, damaged, or destroyed. Any ecological restoration should follow an adaptive management strategy consisting of a generalized step-by-step plan, whereby each step or management activity performed influences successive steps to be taken with measurable outcomes. A recommended primer is the Society of Ecological Restoration's International Primer on Ecological Restoration (SER, 2004):

1. Contains a characteristic assemblage of the species occurring in an ecologically similar reference ecosystem. Kessler Mountain, or a similar natural area managed for biodiversity, is a good reference.

2. Consists of indigenous species to the greatest practicable extent. Any replanting or vegetative introduction should incorporate flora indigenous to Washington County. Ideally, this would be limited to plants produced in a desirable ecotype to avoid genetic contamination and reduction in survivability.

3. All functional groups necessary for the continued development, stability, or both are represented or, if they are not, the missing groups have the potential to colonize by natural means. Functional groups, such as wetland indicator status and growth habit, should be tailored for the site in which they are being introduced. Poor functional group matchup can result in multiple undesired results, such as low survivability or exclusion of desirable species.

4. The physical environment is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory. Removing and monitoring competing vegetation, such as non-native invasives, or opportunistic natives like eastern red cedar and black locust from both above grounds and the seed bank may be necessary for a successful re-establishment of native vegetation to occur.

5. The ecosystem is suitably integrated into a larger ecological matrix or landscape.

6. Potential threats originating from the surrounding landscape have been eliminated or reduced as much as possible. The reduction of non-native invasive species inputs will be a major factor affecting future management actions.

Pursuing management actions meeting the parameters of this primer increases the likelihood any management goals and subsequent actions will be managed for the natural communities inherent to the site, not forcing the site along a poorly suited ecological trajectory. Implementing management practices which are inappropriate for the target ecosystem, such as applying prescribed fire, a practice perfectly suited to an upland woodland, to a mesic riparian forest, can cause unintended harm to the ecosystem and could trigger an unforeseen and undesirable response by the ecosystem.

Adaptive Management

Any management action in an ecosystem is accompanied by any number of ecological reactions, ranging from subtle to extreme. Since the influences driving these responses are unique to the ecosystem being managed, any management plans must be flexible and attempt to predict these reactions.

Developing an adaptive approach to ecological management helps minimize uncertainty by identifying positive and negative ecological influences. Negative influences are identified, and a hypothetical response is considered if action is taken to remove that influence. For example, a thorough botanical survey would identify the presence of a dominant invasive understory shrub species, as well as the presence of a smaller population of another invasive plant species whose population is controlled by the more-populous invasive species. If removing the dominant species creates an ecological "power vacuum," then the second species may explode in population and replace the first as the primary nuisance species. Predicting this "ecological release" suggests a better action by the manager would be to remove the second species first so as not to replace one problem species with another.

Ecological Stressors: Non-native & Invasive Plant Species

Mill Branch Park has several species of exotic-invasive plant species typical to lands near urban centers. If unchecked, these species can cause the displacement of native species, wholly altering the composition and disrupting the natural function of the site's structural diversity, wildlife

habitat, and various ecosystem services like nutrient cycling, as well as reduce aesthetic appeal and accessibility to attractive natural features in the park. New research in infectious diseases is also increasingly indicating a positive relationship between non-native invasive species density and the spread of tick-borne diseases (Allan et al., 2010). Removal of these species would benefit both native flora and fauna, as well as improve Mill Branch Park's aesthetic value and vital ecosystem services. The book "A Management Guide for Invasive Plants in Southern Forests" by the U.S. Forest Service is incredibly valuable (Miller, Manning, & Enloe, 2013). Other species-specific information on invasive-species management strategies can be found through the Missouri Department of Conservation.

Several initial species were documented during the various site assessments and surveys: Amur honeysuckle, fragrant honeysuckle (*Lonicera fragrantissima*), Chinese privet (*Ligustrum sinense*), creeping euonymus (*Euonymus fortunei*), Asian bittersweet (*Celastrus orbiculatus*), tree-of-heaven (*Ailanthus altissima*), multiflora rose (*Rosa multiflora*), and Japanese stiltgrass (*Microstegium vimineum*) currently pose the most significant invasive potential and have healthy populations throughout the woods. Callery pear (*Pyrus calleryana*) and empress tree (*Paulownia tomentosa*) are present and, while presently found in small populations, possess the potential to become significant nuisances as the more-dominant species are removed. Chinese bush clover (*Lespedeza cuneata*), perilla mint (*Perilla frutescens*), and Japanese honeysuckle (*Lonicera japonica*) are present along edges where sunlight is abundant and significant soil disturbance has occurred. Other potentially invasive plant species noted within Mill Branch Park, in proximity, or otherwise posing less-immediate invasive potential than the initially listed species were: Persian silk tree (*Albizia julibrissin*), Asiatic dayflower (*Commelina communis*), deadnettle (*Lamium purpureum*), rough cinquefoil (*Potentilla recta*), common chickweed (*Stellaria media*), and common dandelion (*Taraxacum officinale*) were also recorded.

Some native species have superficial similarities to some of the exotic invasive species listed above. Coralberry (*Symphoricarpos orbiculatus*) is superficially similar in appearance to amur and fragrant honeysuckle. Many native plums, including the Mexican plum (*Prunus mexicana*), found on-site, are often confused with callery pears due to their similar flowers, bark, bloom time, and occasional thorns on some native plum species. Deciduous holly (*Ilex decidua*) is often removed by volunteers because its bark and foliage look very similar to Chinese privet. Anyone, especially volunteer

groups, removing invasive species should be made aware of these lookalikes to prevent accidental removal!

Ecological Stressors: Deer Pressure

Invasive exotic species can do significant damage to native plant populations, but a factor often overlooked is the impact whitetail deer can have on ecosystems. Deer, in the absence of natural predators, can substantially alter the floral community of forests, especially forests with limited browsing options due to occluded canopies. Deer can have a devastating impact on early emerging vegetation, particularly on geophytes or "spring ephemerals." Increasing forage capacity through basal area reduction would help reduce both the dependency and pressure of deer on the limited herbaceous coverage and would increase the survivability of new plants becoming established.

Browsing pressure by deer increases disproportionately as habitat fragmentation concentrates deer populations in urban forests and greenspaces. Browsing pressure can be further exacerbated by an occluded or "closed-off" canopy, resulting in limited sunlight and subsequent lack of grasses, forbs, and reduced mast (acorn) production. A study conducted in 2013 and early 2014 at Lake Atalanta Park in Rogers found exceesively dense deer populations can have a substantial negative impact on native flora populations. Other studies found excluding deer can have profound benefits to wildflower populations, especially those emerging in spring (Webster, Jenkins, & Rock, 2005). A similar study could be conducted at Mill Branch Park to estimate browsing pressure by deer by erecting a temporary exclosure – a tall fence to keep out deer – for a growing season or a few years.

Fire History of the Ozarks and Prescribed Fire

Many North American upland ecosystems, especially those in the Ozarks, are fire-adapted (Nelson, 2012). Predating European colonists, wildfires, started by lightning strikes or by First Nations peoples to cultivate game and forage (Jurney. 2012), frequently raged unabated atop the hills and down the slopes of the Ozarks until exhausted or extinguished by rain (Rudis & Skinner, 1991). Indigenous plants have adapted to this disturbance cycle by developing extensive root systems and the ability to resprout quickly after fires.

Much of North America's flora is adapted to fire, especially oaks and pines. Most exotic species, however, aggressively spread their roots out in shallow soil to quickly reach available nutrients. Though the Boston Mountains experience fewer, less intense fires than the Ozark Plateau, occasional burning of excess organic matter was historically common (Miller, 1972). As these fires were suppressed and the surrounding landscape fragmented by development, the health and diversity of these woodland and forest sites have declined. When appropriate, prescribed fires are used to promote diverse ecosystems which are more resilient and resistant to internal and external stressors, such as encroaching invasive species. Historically, wildfires, whether driven by lightning strikes or initiated by Indigenous Peoples to enhance foraging grounds, would sweep through forests and woodlands of the Boston Mountains and the Ozark Plateau every 3-5 years. These fires would burn most intensely on southern and western facing slopes, especially on elevated hilltops. Eastern-facing slopes would occasionally burn at a low intensity, with streams and river bottoms burning little due to their high soil moisture. Fire removes excess leaf litter and recycles nutrients in the form of leaves, sticks, and debris back into the soil, but also act as a cheap and effective means of reducing the density of woody vegetation, encouraging fewer, but significantly healthier, trees to grow while also removing diseased individuals and unsuitable species. The result is an increase in desirable forbs and graminoids, which thrive under the improved sunlight and act to compete with future invasion by non-native invasive species, as well as a steady production of healthy saplings to replace old trees as they die off naturally.

Fire alone is a tool and, while not appropriate for every scenario, it can be a significant component in cheaply and effectively managing forests. However, like any tool, if applied inappropriately can cause severe damage and set back management goals (Thomas, 2020). Prescribed fire, when used appropriately, can help maintain a healthy understory canopy so young trees can mature without competing for light, space, nutrients, and water. Fire also consumes the excess leaf litter, which holds moisture, bacteria, parasites, and harmful fungi, as well as prevents grasses and wildflowers from germinating, converting the excess litter into available nutrients for trees and herbaceous plants. Prescribed fire is a valuable management tool which simulates an integral part of Arkansas ecosystems' natural ecological cycle to which Ozark species are adapted, ultimately maintaining forest vitality, biodiversity, and wildlife habitat.

Where prescribed burning is not appropriate, such as near streams, excess stands of small shrubbery and competing vegetation should be thinned by hand crews. Where slope and accessibility permit, a brush mower or skid steer with a mulcher attachment, often called a "forestry mulcher," can be a relatively cheap and effective option for treating large areas. When treated with a mulcher, dense stands of invasive shrubbery often leave a thick mulch layer. Typically, this treatment results in a uniform layer of emerging regrowth, which is best treated with a foliar herbicide application in the fall once non-target species begin to go dormant. Brush mulching and cut-stump treatments should not be used simultaneously, as the stumps will be buried under the mulch and may miss treatment. If the aesthetic value of decomposing brush is not a concern, such as in remote locations with minimal traffic and if the target species does not currently bear fruit, then crews can "cut and drop" vegetation to decompose gradually, or haul out, or allow to be burned via prescribed fire when and where appropriate.

If planning a prescribed burn, a canopy thin is critical for the prescribed burn to be successful, as a closed canopy can prevent the site from becoming dry enough to sustain a clean and effective burn. Maintaining a healthy and productive forest beneficial to wildlife requires simulating the natural and historic disturbance patterns, which created healthy biodiversity and prevented the homogenization associated with advanced forest succession. A burn prescription would assign zones appropriate for burning into "burn units," the units often individually scheduled on 3–5-year rotation to ensure flora and fauna have ample ability to recover. Burns should only be conducted during dormant seasons to prevent damage to non-target plants, ground-nesting birds, and slower fauna which would be unable to escape. Any burn zones require fire breaks, which should be installed well in advance of any burn to prevent damage to private and public property. Fire breaks must comply with the Arkansas Department of Agriculture's Division of Forestry guidelines as prescribed in a Forestry Management plan, obtainable through a county forester and can be implemented by the Forestry Division or by the landowner themself, whereas the prescribed burn can be conducted through the Forestry Division or in cooperation with a prescribed burn association such as the Ozark Prairie Chapter of the Arkansas Prescribed Burn Association.

Fire Suppression and **Canopy Occlusion**

Canopy occlusion is most often caused by the removal of fire from the landscape or "fire suppression," a change favoring exotic and potentially invasive species, especially understory shrubs and vines, over indigenous species. Fire suppression has fundamentally altered the foundation of historic disturbance cycles, radically changing the landscape of Ozark forests and grasslands (Guyette, Muzika, & Dey, 2002).

Signs of an excessively dense or occluded (closed off) canopy are:

- The vast majority of trees' trunks are < 3ft. in diameter.
- Trees' limbs tend to have sharper angles between them and the trunk or have a majority of limbs exclusively on one side. These are expressions of phototropism, whereby plants alter their physiology to better compete for limited resources (in this case, light).
- An untraversable "undergrowth" of densely growing seedlings which appear thin, twisted, and unhealthy looking.
- An abundance of vining species such as greenbriar (*Smilax spp.*), bittersweet (*Celastrus orbiculatus*), wintercreeper (*Euonymus fortunei*), English ivy (*Hedera helix*), or Japanese honeysuckle (*Lonicera japonica)*.
- A heavy green understory in late fall or early spring, indicating the dominance of exotic shrubbery such as privet (*Ligustrum spp.*), bush honeysuckle (*Lonicera spp.*), burning bush (*Euonymus alatus*), nandina (*Nandina domestica*), or autumn olive (*Elaeagnus spp.*).
- Scant sunlight on the ground floor during the height of growing season – healthy woodlands should have at least some sun dappling on the ground.
- Bare earth ground floor – lack of sunlight prevents any vegetation from becoming established. These sites are highly susceptible to soil erosion.
- A thick, musty layer of leaf litter, often several inches deep – the inability of fine-rooted vegetation to establish also prevents mycorrhizal fungi from becoming established, significantly reducing leaf litter decomposition and creation of organic soil.

The dense, brooding forests present in contemporary North American landscapes, particularly near urban centers (Fig. 20), took many decades to develop. The institution of fire suppression, fueled by the view of fire as a fundamental threat to development, has removed this unique and necessary regenerative feature from our landscape and has had the unforeseen consequence of promoting the proliferation of non-native invasive species in natural areas and expediting the decline of numerous plant and animal species. Although open forests and woodland were historically abundant, they have become exceedingly rare.

Excessively dense or “occluded” forest canopies prevent sunlight from reaching the forest floor, shifting the local environmental conditions to a state which no longer supports them while often supporting exotic invasive competitors. In heavily occluded forests, native grasses, forbs, and even saplings are completely shaded out as established plants or those requiring less sunlight dominate. Saplings futilely compete for limited sunlight, growing twisted, unhealthy, developing poor root systems, often becoming hollow if they do manage to reach maturity. These short, twisted, and sickly trees are susceptible to being overtaken by aggressive native vines like greenbrier and American bittersweet as well as invasive exotic species like Japanese honeysuckle, wintercreeper, and Asian bittersweet. These vines’ mass bend over and “lodge” already struggling seedlings under a brooding mound of vines. Maintaining healthy canopy density allows sunlight to reach the forest floor, encouraging native grasses, wildflowers, and saplings to mature and replace older trees as they die off. Maintaining a healthy canopy also increases airflow, reducing plants’ susceptibility to disease.

Figure 20: Canopy occlusion (seen here) prevents sunlight from reaching the forest floor, discouraging desirable grass and forb growth while encouraging vines, unhealthy tree growth, and invasive infestation.

Ecological Thinning or Timber Stand Improvement

Performing an ecological thin or timber stand improvement can help increase the biodiversity and general vitality of a forest or woodland and is primarily meant to prioritize the removal of invasive woody species and reduce tree stand density to open the forest canopy, especially in preparation for long-term management with prescribed burns. Tree stand density, often measured in square feet of basal area per acre, can be determined by a forester. The thinning itself can be performed either commercially or non-commercially but should also be performed by a certified forester to prevent timber theft. A mature tree can be worth thousands of dollars, depending on the size, species, and quality of the tree. Timber stand improvement uses a technique called “hack and squirt” (Fig. 21) to remove trees of a diameter class, species, or a combination thereof to improve productivity, survivability, and recruitment of the desired species to increase diversity. A hatchet or machete is used to make several small cuts into the tree’s cambium layer, into which an herbicide is

injected. An alternative practice is “cut and paint” (Fig. 22), whereby smaller woody vegetation, often multi-stemmed shrubs, are cut low to the ground and the herbicide “painted” on the stump. This practice is preferable when numerous dead trees are a safety concern or would be unsightly, although this technique is more labor-intensive than “hack and squirt.” Both methods can be used to thin an excessively dense canopy or cull undesirable species, such as exotic invasives.

Herbicide selection and rate will depend on target species and should be determined by a licensed herbicide applicator. Invasive species such as Chinese privet, bush honeysuckle, tree-of-heaven, Persian silk tree aka “mimosa,” and princess tree are high-priority examples found at Mill Branch Park. Maintaining an open canopy allows sufficient sunlight to reach the forest floor, allowing grasses and wildflowers to thrive, encourages soil health, increases root size diversity, and conditions the site for management with prescribed fire or analogous practices like mowing.

Dead trees do very little to obstruct sunlight and should only be removed if they are a safety hazard, pose a snag concern when considering a prescribed burn, or if they are overtaken by a nuisance species to reduce exposure to healthy trees. Dead trees offer critical habitat to birds like woodpeckers and owls, provide a source of slow-release nutrients to the ecosystem, and should be left intact to provide habitat and structural diversity.

Figure 21: Example of "hack and squirt" canopy thinning technique. Several cuts are made into the cambium layer of a mature tree, usually with a hatchet. An herbicide is then applied into the cuts, often with a squirt bottle. Source: Woody Invasives of the Great Lakes Collaborative.

Figure 22: Bush Honeysuckle stump, treated with "cut and paint" technique. The blue is a marker dye to indicate successfully treated stumps. This method allows precise targeting of undesirable species and is recommended for understory shrubs. Photo by Nate Weston, Beaver Watershed Alliance.

Pasture Conversion to Prairie

Converting former cattle pasture to indigenous grasslands would immensely improve the ecological value of Mill Branch Park, especially to wildlife enthusiasts and students. Establishing indigenous grassland species would require the complete removal of all exotic pasture grasses before the establishment of indigenous species could begin. Treating the exotic pasture grasses and forbs with an appropriate application of selective herbicides, available through the Arkansas Game & Fish Commission's Acres for Wildlife program, for at least two years prior to introducing native species, would provide the best opportunity native species to become established with minimal competition from exotic species. Following establishment, the periodic application of prescribed burning would be the preferred management method, but an annual mowing could provide an early alternative to burning, especially when the vegetation density is not yet established well enough to sustain a prescribed fire. Mowing also simulates the historic disturbance cycle of periodically intense grazing by prairie herbivores like American bison (Collins, Knapp, Briggs, et al., 1998). Mowing should be done once annually, ideally during late summer (between August 15th and September 15th), with blade height no lower than 8 inches to avoid cutting smaller vegetation and encourage a healthy recovery by the plant community.

Quick reference recommendations:

Use adaptive management to predict and mitigate ecological stressors created through management actions. Simulate historic disturbance patterns like fire and periodically intensive grazing - use analogs like rotational burning, mowing, or grazing. Prioritize increasing structural diversity and avoid big patches of ecological "sameness" and "clean lines" – nature likes clumps. Thin excessively dense tree canopies to promote new growth, biodiversity, and manageability. DON'T BURN IN THE GROWING SEASON. Leave dead trees for wildlife unless they pose a risk of falling along a trail, damaging property, or pose a risk of spreading fire across fire breaks. Hydrate the landscape by keeping water on-site and establishing indigenous prairie to increase wildlife habitat.

Management Zones

The management zones outlined in this section (Fig. 23) are a general guide for management planning; the boundaries thereof should not be considered "hard" as they do not separate Mill Branch Park's various ecological features. These features will blend, overlap, and share similarities with one another across management zones. Each zone is given a brief description of its features, challenges, opportunities, and recommendations for actions to be taken specifically to that zone.

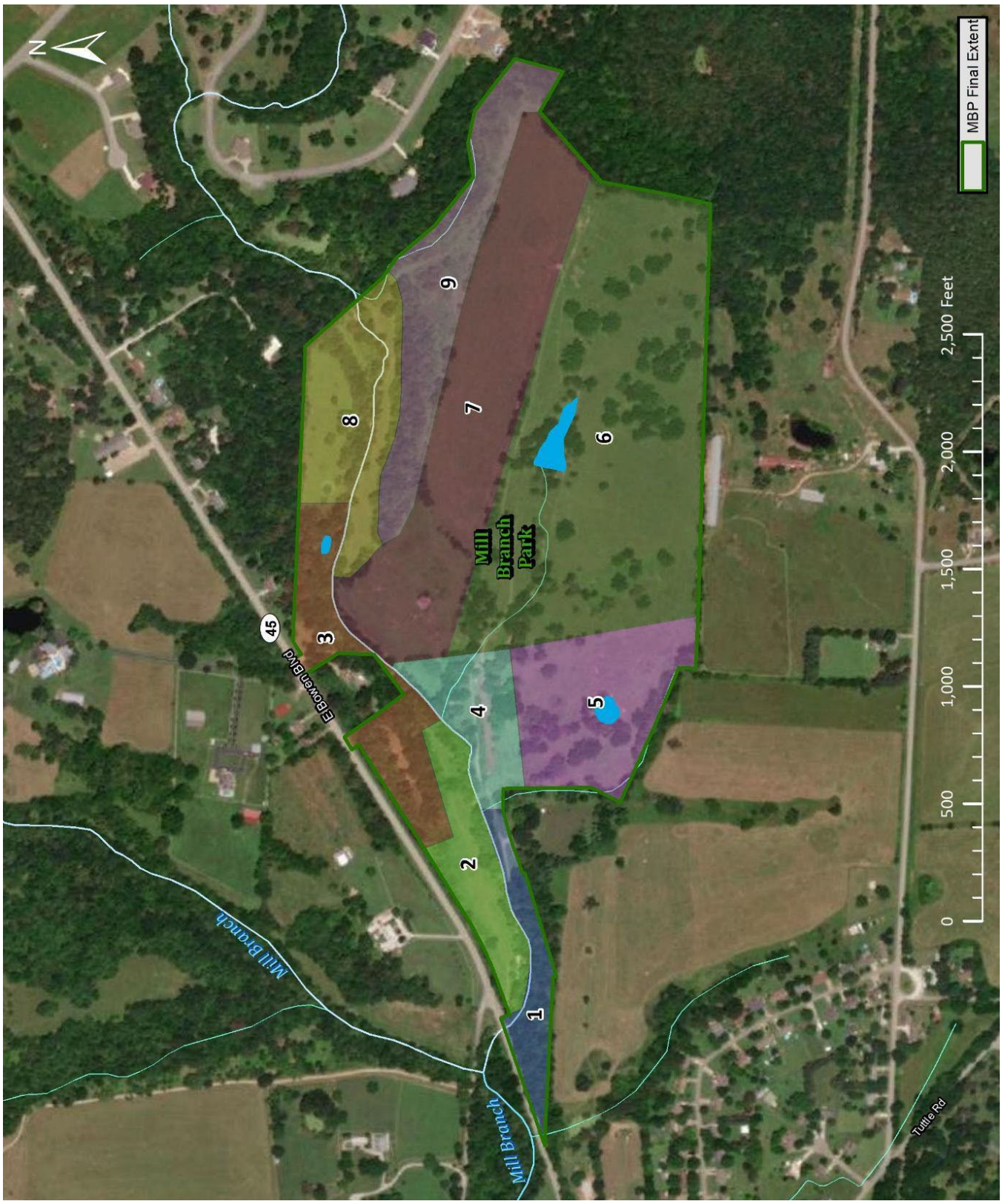


Figure 23: General management zones 1-9 for Mill Branch Park, based on site features, topography, and presence of barriers such as fencing, cliffs, streams, etc. These zones should be considered general recommendations and not "fixed" as site conditions can change with management.

Zone 1

This zone is characterized by steep slopes; numerous small groundwater seeps flow from the north slope and feed the stream below, which is paralleled by gravel roads above and below. There is a meager riparian buffer between these roads and the stream, but steep slopes in the case of the southern side and sheer proximity make sediment transport a great concern. The two current access roads enter Mill Branch Park through the north and south borders of zone 1, with the north access road fording the unnamed stream. Native rye grass (*Elymus sp.*), wingstem (*Verbesina alternifolia*), mistflower, bellflower, and both orange and pale jewelweed can be found here. This zone should be wonderful in the spring (mid-late April) and should have numerous geophytic or "spring ephemeral" plants appearing on the northern slope and around the stream. The canopy here is very mature and shows signs of being too dense – it would likely benefit from being thinned to about 65% of its current density. Any thinning should maintain a moderately dense canopy in eastern and northern facing slopes but allow sufficient sunlight to reach the forest floor so healthy young growth can replace older plants as they die off. In thinning, prioritize the removal of trees and shrubs in the order of invasive species, opportunistic natives like cedar, then unhealthy and crowded seedlings, and finally culling of individuals in competition with species considered to have greater conservation value. Even with thinning, this zone will not be receptive to prescribed burning, being a north-facing slope and adjacent to a stream.

Due to steep slopes converging from the north and the road itself, this site is bottlenecked. Roads have a significant impact on riparian ecosystems, especially when topography necessitates the road be constructed near streams. Roads transform the landscape's physical conditions, creating edge effects which persist beyond the duration of the road's construction. Soil density, surface temperature, soil water permeability, light availability, dust, surface-water flow, runoff patterns, and sedimentation can all be affected by the presence of a road, the material used in constructing and surfacing the road, traffic volume, and the subtle changes of topography associated with road construction and operation (Trombulak & Frissell, 2000). Ideally, moving the road at least 100ft away from the stream would reduce its impact on this sensitive riparian zone. At a minimum, paving the road, constructing water-runoff bars to disperse water off the road's surface incrementally, and installing semi-permeable "checks" along designated drainages along the

roadside would slow and disperse stormwater, reducing the road's impact and minimizing erosion in the streambed.

The passage of numerous vehicles across the ford here can also cause erosion within the crossing itself, increase sedimentation downstream, and the excess dust kicked up by automobiles' passage can damage the sensitive riparian community. Any crossings should facilitate vehicular transport without escalating problems already caused by the zone's topography. Replacing the ford with a deck bridge capable of handling the expected traffic and ensuring the bridge's footers/piers/piles are outside the streambed would prevent changes in hydrologic patterns, which would cause erosion and ecological degradation.

Zone 2

This zone is characterized by its proximity to E. Bowen Blvd. to the north, streamside to the south, and the central pasture, which is small and somewhat isolated from the pastures on Mill Branch Park. A potential drainage bisects this zone, fed by runoff from E. Bowen Blvd. flowing through zone 3, and a small path leading to the east of the zone to a fording connecting zones 2, 3, and 4. The canopy here is predominantly boxelder, hackberry, black cherry, and sycamore with the occasional Persian silk tree. There is an existing footpath which runs along part of the stream, on the north side between the stream and a very steep sloped section of land with some bedrock and vegetation. The riparian buffer area of this stream is lacking in width and appropriate types of vegetation, but a decent population of native rye grasses is scattered throughout the slopes above, which could be cultivated for future planting elsewhere in the park. Establishing an adequate riparian buffer area here would be ideal. Additionally, it will be essential to design strategic access points to this stream as well as a means of crossing the stream which does not interact with the streambed itself, such as a deck bridge with footings/piles located outside the streambed. This site is likely to be a publicly popular water feature on the property due to its scenic nature and high accessibility. Designated access points should reduce the occurrence of people trampling their own path to the water, which would destabilize the riparian vegetation and have a negative impact on water quality.

Zone 3

This zone is situated on a warm, south-facing ridge overlooking the main stream valley bisecting Mill Branch Park. Characterized by steep slopes to the north of the stream, zone 3's southern slopes are fertile, possessing stands of native hydrangeas, pawpaws, oaks, hickories, and sycamores. The herbaceous layer here is very diverse, though due to the steep slopes and limited accessibility, it has been given only a cursory survey. Dense patches of native rye grass are also found here. In the southernmost section, a pathway connecting zones 2, 3, and 4 fords the stream at a sharp angle, also where the slopes converge on the stream. Two small ephemeral drainages coming off E. Bowen Blvd. enter Mill Branch Park through this zone. There are signs here of erosion due to repeated cattle crossing – this would be a promising footpath, but such a feature would need a structure suitable for this location's sharp angle and steep slopes. A slight depression, possibly a pond or sinkhole depression, is located on the eastern side, just north of the stream. This feature was not observed until after site assessments were completed. The steep slopes along the southern portion have some talus debris small pieces of stone which have chipped off due to erosion/weathering and lay at the base of the bluff. These can be dangerous and a fall hazard, as well as often providing habitat to some rare plants and animals. Consider providing this area a wide buffer or posting warning signs along these slopes. A seemingly abandoned path runs east-west in the northeast corner of the zone, crossing a drainage to access the northwest corner of zone 8 north of the perennial stream. This path appears to have access to E. Bowen Blvd. between the addresses of 675 and 789 E. Bowen Blvd. but looks very steep.

Zone 4

This zone is characterized by the primary arterial road of Mill Branch Park, a decommissioned poultry house in the center, the stream to the north of the road, a floodplain area in the northern-most section below the road and a small wetland area created by the spring to the east. As of the writing of this management plan, the 430ft. long poultry house has been demolished, but the concrete foot remains. There is potentially substantial surface runoff coming from a drainage to the southwest, but a permanent stream bed seems to be absent at this location for reasons unclear. The dominant canopy coverage here is sycamore. The floodplain area in the northern section is heavily

dominated by wingstem (*Verbesina alternifolia*). The herbaceous layer around the structure itself is predominantly pasture grasses.

Zone 5

This zone is characterized by a small pond in the center, scattered hardwood trees, and a small ephemeral drainage bordering the south and west sections. The canopy here is a diverse mix of elms, oaks, walnut, hackberry, and mulberry with an understory dominated by pasture grasses. A very faint path leads south towards a gate in the southeast corner, connecting it to zone 6. A single purple milkweed (*Asclepias purpurascens*), the only one seen here, was discovered just east of the pond in this zone. The stream is densely vegetated with no apparent access. Since this appears to be a stream on the boundary with existing riparian vegetation, management activities might be prioritized elsewhere on the property. The pond has a relatively small drainage area but due to livestock access is highly eutrophic and often entirely covered in aquatic plants (primarily duckweed and watermeal), algae, or both during the growing season.

Figure 24: The small pond (#2), showing an abundance of aquatic vegetation due to nutrient loading. Photo by Erin Scott, 2021-07-29.

Figure 25: Prolific duckweed seen on pond #2 due to excess loading of nutrients from livestock. Note the pile of cattle manure (foreground). Photo by Erin Scott, 2021-09-12.

Zone 6

This zone contains a small ephemeral stream flowing east to west in the central part of the property, which appears to drain the large pond and a small amount of the surrounding landscape. The streambed is characterized by steep slopes as it travels downhill to the confluence with the larger stream flowing through the northern half of the property. Because this stream flows down a steep gradient, establishing an adequate riparian buffer area (same application as described in the previous section related to ponds) with in-stream structures is essential to slow the water down, reduce water velocity, allow for infiltration into the soil profile, and control erosion. These structures may include water-tolerant trees and shrubs as well as a series of weirs. Dissected by numerous headwater drainages feeding the central pond, Zone 6 has perhaps the most potential in Mill Branch Park for restoration, especially for improving the water quality within the pond itself. This pond has a packed-earth dam on the western end with an eroding spillway on the southern side. The pond also has steep slopes descending into it, resulting in the need for broader buffer areas to intercept fast-flowing sheet runoff. Numerous gullies are also starting to form downstream of the pond as cattle migrate across the various drainages. Rehydrating these drainages with semi-

permeable structures such as weirs, check dams, beaver dams, post-assisted log structures, or beaver dam analogs would retain some water, gradually raise the water table, reduce erosion and sedimentation, and encourage vegetation to re-establish. Without restoration, these drainages will continue to deepen into unsightly gullies and ravines. Rehydrating these drainages would replenish the diminished water table here, allowing trees, shrubs, and smaller plants access to critical groundwater resources while gradually reversing the ongoing gully erosion here. If allowed to rehydrate, these gullies would slowly fill in with sediment, reducing nutrient input downstream, increasing groundwater recharge, becoming sources for wildlife refuge, and generally being hotspots for plants and wildlife.

A perennial spring located in the far northwest corner of this zone feeds into the main stream to the northwest. The slight rise above the spring box has a few pawpaw trees on it. Several stands of mature, stately black walnut trees form a picturesque savanna overlooking the pond and Mill Branch Park. These tall walnut trees offer great potential for scenic and biologically valuable savannas, grasslands where mature trees' trunks are 75-100 feet apart. This spacing affords grasses and wildflowers ample sunlight while offering shelter and hosting opportunities for birds and insects in the trees. Savanna habitats provide a happy medium between canopy cover and sunlight availability, providing shelter and forage for birds and insects as well as reinforcing the soil with both large and small roots. Along the northern perimeter, there is a row of piled stones approximately 520ft. long, likely produced during the excavation of the pond immediately to the south. Stone clusters like these provide habitat for reptiles and amphibians; leaving them would be preferable unless they could be incorporated into structures such as check dams for the drainages. A small cluster of mature, red-barked gum bumelia (*Sideroxylon lanuginosum*) trees line the fence in the north-central section, just west of the row of piles stones. The open area immediately to the northwest of the central pond possesses some remnant prairie species, including lady's tresses, orange milkweed, orange coneflower, and western ironweed.

The drainages associated with "E" have reduced water retention due to intensive cattle pressure, resulting in a lowered water table and progressively dehydrated and diminishing riparian zone, and visible reduction in canopy coverage over recent decades. These headwater drainages would likely benefit from an increase in their structural complexity once sustained access by cattle is removed.

Temporary rainwater storage systems such as weirs or semi-permeable dam structures paired with check systems would rehydrate this network.

Figure 26: The large pond (#1) as seen from the earthen dam, facing east. Photo by Erin Scott, 2021-07-29.

Figure 27: Blanket of duckweed and watermeal in the large pond (#1). Photo by Erin Scott, 2021-09-12.

Zone 7

This zone shows the most disturbance from sustained cattle grazing –there is no vegetation in this zone that is indigenous except for the few trees and shrubs scattered along the stream to the northwest and perimeter fences. The few indigenous species seen were aggressive opportunist species (locusts, winged elm, boxelder, etc.). This zone suggests good opportunities for pasture conversion into an indigenous prairie due to the fertile soil. Pods of thicket-forming native shrubs like native plums or sassafras would be ideal along the peripheries here.

Zone 8

This zone contains a large stream flowing along the northern portion of the property, which originates outside the property boundary, draining over 100 acres of land area. Only the section south of the stream was surveyed for this zone. A primitive path, barely evident in most locations, connects the north section and south via two fords on the west and east ends of the zone, the path winding around the northern perimeter. A possible vernal pool is located on the southern edge of

this zone, wedged between it and zone 9 to the south. This vernal pool is a slight depression along the entire base of the ridgeline where water pools, deposits fine sediment, and flows west, along the bottom of the ridgeline instead of flowing north towards the stream (see stormwater accumulation map). This site has potential as a large vernal pool, a critical breeding site for many amphibians such as frogs and salamanders. Consider clearing out the colonizing stand of boxelder and encouraging water to pool here. The single deciduous holly tree found in Mill Branch Park was found along the south side of the stream somewhere around the western ford.

Zone 9

This exceptionally diverse zone, with mature American hophornbeam, black tupelo, pawpaw, and mulberries along its north-facing ridge, overlooks the perennial stream bisecting Mill Branch Park. The northwestern section is relatively undisturbed, though cattle were observed to trot down the western edge during multiple site visits. This slope is steep but scalable and offers a good assortment of attractive early spring wildflowers such as black cohosh, Solomon's plume, and likely several other spring wildflowers if visited in mid-late April and early May. Most of the southern edge along zone 7, especially along the path connecting zones 7 and 8, shows significant signs of early successional colonization following sudden cessation of clearing activities ca. 2009. The trails and fence perimeters in this zone are overgrown with mainly opportunistic native species such as brambles, boxelder, winged elm, etc. The northeast slope drops off gradually in most places but is steep in the central section, towards the drainage wrapping around Mill Branch Park from the southeast. At least one native plum, likely Mexican plum (*Prunus mexicana*), was found along the far-eastern fence just by the gate accessing zone 7. There is also a slight depression along the border of zones 4 and 5, which holds moisture from groundwater seeping out of the hill above as well as holding water when the stream floods. This site looks to have been historically more open, but a dense stand of young boxelder is now colonizing it. Spicebush is the dominant understory shrub along the slopes, with occasional gooseberry and pawpaw.

Biodiversity Assessments

Numerous in-person site visits by Alliance staff as well as Ken Smith were conducted in spring and summer 2021, followed by two citizen-science biological surveys completed in summer and fall 2021. A total of 253 species were documented through numerous visits by Beaver Watershed Alliance staff, as well as from observations made by visitors using the citizen-science app, iNaturalist (Fig.). Species of high conservation value were also found on Mill Branch Park, such as the Oklahoma salamander (*Eurycea tyrenis*) and pale jewelweed (*Impatiens pallida*). Of the species 207 documented, 31 or roughly 15% are considered not native to North America and potentially invasive. Invasive species are characterized by their ability to displace native populations, disrupt natural communities, and reduce overall ecosystem services. The invasive species should receive priority for control. Continued inventory work should also be conducted during spring, summer, and fall to complete the plant species list and evaluate the presence and density of non-native species. No timber stand assessment has been conducted for this site. No official botanical survey has been completed for this site.

Figure 28: Photos taken during volunteer bioblitz events in summer and fall 2021. Going clockwise, from top left: great blue lobelia (Lobelia siphilitica); Volunteer Tom McClure is resting on a branch of a huge black walnut tree on the savanna; yellow-collared scape moth (Cisseps fulvicollis) nectaring on purple milkweed (Asclepias purpurascens); cave salamander (Eurycea lucifuga).

Plantae

Scientific Name	Common Name
Acer negundo	Boxelder
Acer saccharinum	Silver maple
Actaea racemosa	Black cohosh
Adiantum pedatum	Northern maidenhair fern
Ailanthus altissima	Tree-of-heaven
Albizia julibrissin	Persian silk tree
Amaranthus retroflexus	Redroot pigweed
Amaranthus spinosus	Pigweed
Ambrosia artemisiifolia	Annual ragweed
Ambrosia trifida	Giant ragweed
Amphicapaea bracteata	American hog-peanut
Arctium minus	Lesser burdock
Arisaema dracontium	Green dragon
Asarum canadense	Wild ginger
Asclepias purpurascens	Purple milkweed
Asclepias tuberosa interior	Orange milkweed
Asimina triloba	Pawpaw
Asplenium plyneuron	Ebony spleenwort
Boehmeria cylindrica	False nettle
Campanulastrum americanum	Tall bellflower
Campsis radicans	Amercan trumpet vine
Carex vulpina	Fox sedge
Carya cordiformis	Bitternut hickory
Carya illinoinensis	Pecan
Carya ovata	Shagbark hickory
Carya tomentosa	Mockernut hickory
Celtis laevigata	Sugarberry
Celtis occidentalis	Hackberry
Chamaecrista nictitans	Sensitive pea
Chasmanthium latifolium	Inland wood oats
Cirsium vulgare	Bull thistle
Clematis catesbyana	Satincurls
Commelina~	Dayflower
Conoclinium coelestinum	Blue mistflower
Crataegus collina	Dotted hawthorn
Croton glandulosus	Tropic croton
Cynodon dactylon	Bermuda grass
Cyperus globulosus	Globe sedge
Datura stramontium	Jimsonweed
Daucus carota	Queen Anne's lace
Dianthus armeria	Deptford pink
Diospyros virginiana	Common persimmon
Dipsacus fullonum	Wild teasel
Elephantopus carolinianus	Elephant's foot
Elymus riparius	Riparian rye
Elymus virginicus	Virginia wildrye
Erigeron	Fleabane
Euonymus alatus	Burning bush
Euonymus fortunei	Wintercreeper
Fleischmannia incarnata	Pink thoroughwort
Geum canadense	White avens
Glechoma hederacea	Ground-ivy

Plantae (Cont.)

Scientific Name	Common Name
Gleditsia triacanthos	Honey locust
Hamamelis vernalis	Vernal witch-hazel
Helenium amarum	Bitterweed
Helianthus annuus	Common sunflower
Heuchera	Alumroot
Ilex decidua	Deciduous holly
Ilex opaca	American Holly
Impatiens capensis	Orange jewelweed
Impatiens pallida	Yellow jewelweed
Ipomoea lacunosa	White morning-glory
Juglans nigra	Black walnut
Juniperus virginiana	Eastern red cedar
Kummerowia	Asian clovers
Lactuca floridana	Woodland lettuce
Laportea canadensis	Canadian wood-nettle
Lemna	Duckweed
Lepidium	Pepperweed
Ligustrum sinense	Chinese privet
Lindera benzoin	Spicebush
Lobelia inflata	Indian tobacco
Lobelia siphilitica	Great blue lobelia
Lonicera japonica	Japanese honeysuckle
Lonicera maackii	Bush honeysuckle
Maianthemum racemosum	False Solomon's seal
Menispermum canadense	Moonseed
Microstegium vimineum	Japanese stiltgrass
Mimulus alatus	Sharpwing monkeyflower
Monarda fistulosa	Wild bergamot
Morus alba	White mulberry
Morus rubra	Red mulberry
Nabalus	Rattlesnake root
Nyssa sylvatica	Black tupelo
Ostrya virginiana	American hop-hornbeam
Oxalis stricta	Yellow wood sorrell
Panicum clandestinum	Deer-tongue grass
Parthenocissus quinquefolia	Virginia creeper
Passiflora incarnata	Purple passionflower
Paulownia tomentosa	Princess tree
Perilla frutescens	Beefsteak plant
Persicaria	Smartweed
Phegopteris hexagonoptera	Broad beech fern
Phlox paniculata	Fall phlox
Phytolacca americana	American pokeweed
Plantago major	Broadleaf plantain
Platanus occidentalis	American sycamore
Polystichium acrostichoides	Christmas fern
Prunela vulgaris	Common Selfheal
Prunus mexicana	Mexican plum
Prunus serotina	Black cherry
Pyrus calleryana	Callery pear
Quercus alba	White Oak
Quercus stellata	Post Oak

Plantae (Cont.)

Scientific Name	Common Name
Quercus falcata	Southern red oak
Quercus marilandica	Blackjack Oak
Quercus muehlenbergii	Chinquapin oak
Quercus rubra	Northern red oak
Ribes missouriense	Missouri gooseberry
Robinia pseudoacacia	Black locust
Rosa multiflora	Multiflora rose
Rudbeckia fulgida	Orange coneflower
Rudbeckia hirta	Black-eyed susan
Rudbeckia triloba	Brown-eyed susan
Rumex crispus	Curly dock
Sabatia angularis	Rose pink
Salix nigra	Black willow
Sambucus canadensis	Elderberry
Sanguinaria canadensis	Bloodroot
Sanicula	Sanicle
Sassafras albidum	Sassafras
Sideroxylon lanuginosum	Gum bumelia
Silphium perfoliatum	Cup plant
Smallanthus uvedalia	Bear's foot
Smilax rotundifolia	Roundleaf greenbrier
Solanum carolinense	Carolina horsenettle
Solidago altissima	Tall goldenrod
Solidago rugosa	Wrinkle-leaved goldenrod
Sorghum halepense	Johnson grass
Spiranthes	Ladies' tresses
Staphylea trifolia	American bladdernut
Symphoricarpos orbiculatus	Coralberry
Symphyotrichium cordifolium	Common blue wood aster
Teucrium canadense	American germander
Tilia americana	Basswood
Toxicodendron radicans	Poison ivy
Tragia urticifolia	Nettleleaf noseburn
Tridens flavus	Purpletop tridens
Trifolium repens	White clover
Ulmus alata	Winged elm
Ulmus americana	American elm
Ulmus rubra	Slippery Elm
Verbascum blattaria	Moth mullein
Verbascum thapsus	Great mullein
Verbena urticifolia	White vervain
Verbesina alternifolia	Wingstem
Verbesina virginica	Frostweed
Vernonia baldwinii	Western ironweed
Viburnum prunifolium	Blackhaw viburnum
Vinca minor	Lesser periwinkle
Viola sororia	Common blue violet
Vitis	Wild grapes
Vitis rotundifolia	Muscadine

Fungi

Scientific Name	Common Name
Artomyces pyxidatus	Crown-tipped coral fungus
Auricularia	Wood-ear fungi
Entonaema liquescens	

Arthopoda

Scientific Name	Common Name
Antheraea polyphemus	Polyphemus moth
Apis mellifera	Western honey bee
Arilus cristatus	Wheel bug
Asellidae	Freshwater isopods
Astacoidea	N. Hemisphere crayfish
Asterocampa celtis	Hackberry emperor
Atalopedes	Grass skippers
Calopteryx maculata	Ebony jewelwing
Celastrina neglecta	Summer azure
Chauliognathus pensylvanicus	Goldenrod soldier beetle
Chloesyne nycteis	Silvery checkerspot
Cisseps fulvicollis	Yellow-collared scape moth
Colias	Sulfur butterflies
Cupido comyntus	Eastern tailed-blue
Erebidae	Tussock moths
Eris militaris	Bronze jumping spider
Eusarca consusaria	Confused eusarca moth
Flatormenis	Planthoppers
Gryllus pennsylvanicus	Fall field cricket
Leucauge venusta	Orchard orbweaver
Limenitis arthemis	Red-spotted admiral
Lobocleta ossularia	Drab brown wave
Lycosoidea	Wolf spiders
Neotibicen lyricen lyricen	Common lyric cicada
Noctuidae	Cutworm moths & allies
Odontotaenius disjunctus	Horned passalus beetle
Papilio troilus	Spicebush swallowtail
Parcoblatta	N. American wood roaches
Pieris rapae	Cabbage white
Polygonia interrogationis	Question mark
Popillia japonica	Japanese beetle
Rhynchomitra recurva	
Speyeria cybele	Great Spangled fritillary
Spilosoma	Tiger moths
Vanessa cardui	Painted lady
Verrucosa arenata	Arrowhead orbweaver

Squamata

Scientific Name	Common Name
Diadophis punctatus	Ring-necked snake
Notophthalmus viridescens ssp. Louisianensis	Central newt
Plestiodon fasciatus	Common five-lined skink
Plestiodon laticeps	Broad-headed skink
Storeria dekayi	Dekay's brownsnake
Thamnophis sirtalis	Common garter snake

Aves

Scientific Name	Common Name
Baeolophus bicolor	Tufted titmouse
Buteo jamaicensis	Red-tailed hawk
Cardinalis cardinalis	Northern cardinal
Coccyzus americanus	Yellow-billed cuckoo
Coragyps atratus	Black vulture
Corvus brachyrhynchos	American crow
Corvus ossifragus	Fish crow
Cyanocitta cristata	Blue jay
Dryobates pubescens	Downy woodpecker
Dryocopus pileatus	Pileated woodpecker
Geothlypis trichas	Common yellowthroat
Hirundo rustica	Barn swallow
Icteria virens	Yellow-breasted chat
Melanerpes carolinus	Red-bellied woodpecker
Myiarchus crinitus	Great crested flycatcher
Passerina cyanea	Indigo bunting
Piranga rubra	Summer tanager
Poecile carolinensis	Carolina chickadee
Polioptila caerulea	Blue-gray gnatcatcher
Sayornis phoebe	Eastern phoebe
Setophaga americana	Northern parula
Setophaga discolor	Prairie warbler
Setophaga dominica	Yellow-throated warbler
Sialia sialis	Eastern bluebird
Sitta carolinensis	White-breasted nuthatch
Spinus tristis	American goldfinch
Spizella passerina	Chipping sparrow
Spizella pusilla	Field sparrow
Thryothorus ludovicianus	Carolina wren
Trochilidae	Hummingbirds
Tyrannus tyrannus	Eastern kingbird
Vermivora cyanoptera	Blue-winged warbler
Vireo flavifrons	Yellow-throated vireo
Vireo griseus	White-eyed vireo
Vireo olivaceus	Red-eyed vireo
Zenaida macroura	Mourning dove

Amphibia

Scientific Name	Common Name
Acris blanchardi	Blanchard's cricket frog
Anaxyrus americanus	American toad
Eurycea longicauda ssp. melanopleura	Dark-sided salamander
Eurycea lucifuga	Cave salamander
Hyla versicolor	Gray treefrog
Lithobates catesbeianus	American bullfrog
Lithobates clamitans	Green frog
Lithobates sphenocephalus	Southern leopard frog
Pseudacris crucifer	Spring peeper

Mammalia

Scientific Name	Common Name
Baeolophus bicolor	Tufted titmouse
Buteo jamaicensis	Red-tailed hawk
Cardinalis cardinalis	Northern cardinal

Total Species:	207
Total Invasive Species:	31

Source: observations made by Nate Weston, Ken Smith during in-person site visits as well as observations recorded using the iNaturalist field app for the Biodiversity of Mill Branch Park iNaturalist project.

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