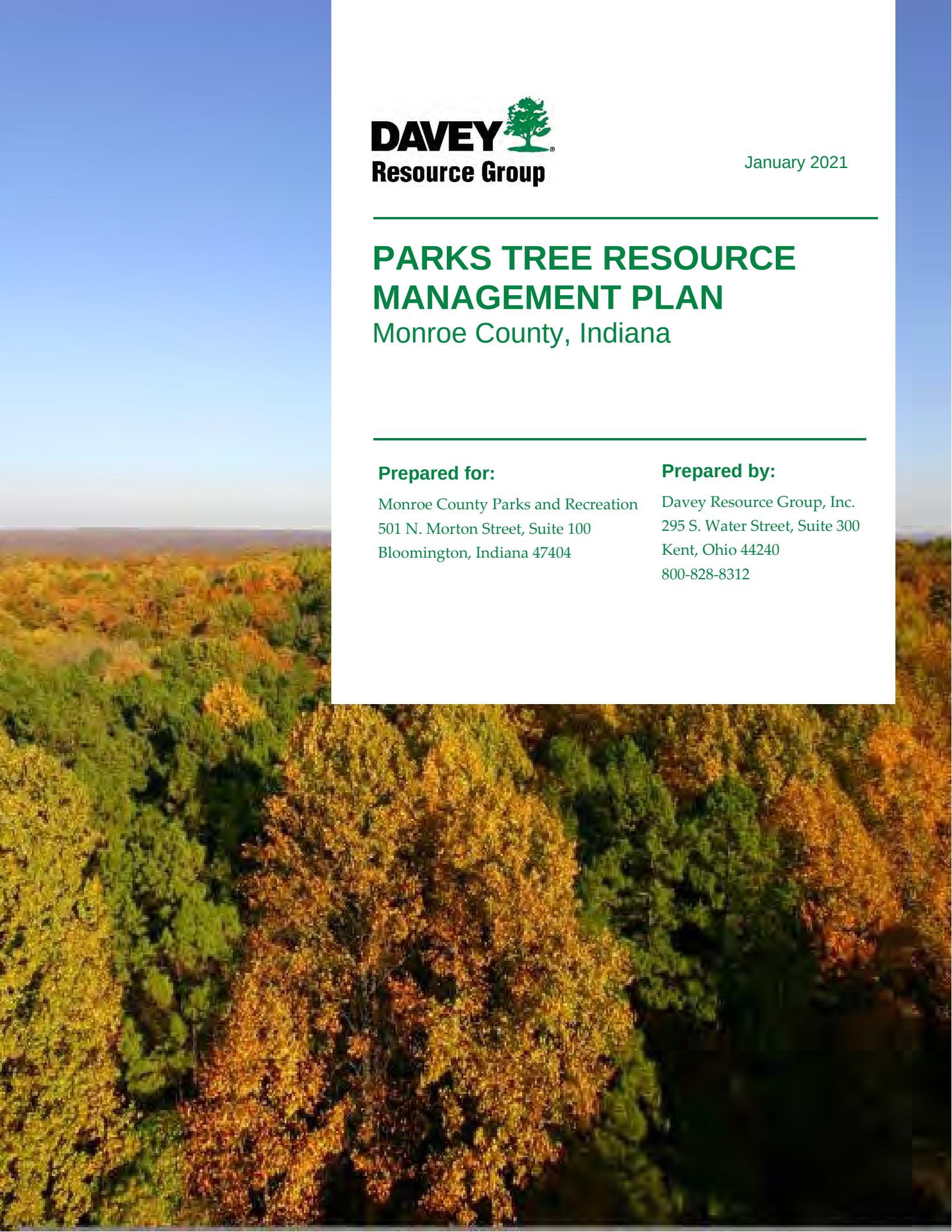

DAVEY Resource Group

January 2021

PARKS TREE RESOURCE MANAGEMENT PLAN

Monroe County, Indiana

Prepared for:

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This tree risk assessment project supports Monroe County's vision to promote safety and reduce liability associated with publicly owned trees. This *Parks Tree Resource Management Plan* offers guidelines and recommendations for reducing risk and improving the environmental, economic, and social benefits of Monroe County's trees for generations to come.

Monroe County is thankful for the grant funding it received from the Indiana Department of Natural Resources, Division of Forestry, Community and Urban Forestry program (IDNR CUF) in cooperation with U.S. Forest Service (USFS) through its Urban and Community Forestry (U&CF) Grant Program. The IDNR CUF grant program is designed to encourage communities to create and support long-term and sustained urban forestry programs throughout Indiana.

Monroe County also recognizes the support of the following people:

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Five-year Parks Tree Resource Maintenance Schedule

EXECUTIVE SUMMARY

The Monroe County *Parks Tree Resource Management Plan*, written by Davey Resource Group, Inc. "DRG", focuses on addressing long-term, proactive maintenance strategies while balancing the safety of trees along county greenways, park trails, and structures. DRG completed a tree inventory for Monroe County in December 2020 and analyzed the inventory data to understand the structure of the county's inventoried tree resource. DRG also estimated the economic values of environmental benefits provided by this park tree resource by analyzing inventory data with i-Tree Eco and recommended a proactive, prioritized management program for future tree care. The goals of the inventory were identifying trees that pose significant or severe consequences and were more likely than not to fail within one year and recommending maintenance to reduce these risks. Supporting and funding proactive maintenance of the parks tree resource is a sound long-term investment that will reduce tree management costs over time.

DRG recommends a five-year management program, Figure 1, that focuses on completing activities to reduce higher risks first. High priority tree removal and pruning is costly, accounting for the larger budget in the first three years of the five-year schedule. After high priority work has been completed, budgets are expected to decrease and stabilize as tree management transitions from reactive to proactive maintenance. This also reduces the number of new elevated risk trees over time by preventing deteriorating conditions of trees with initially minor defects.

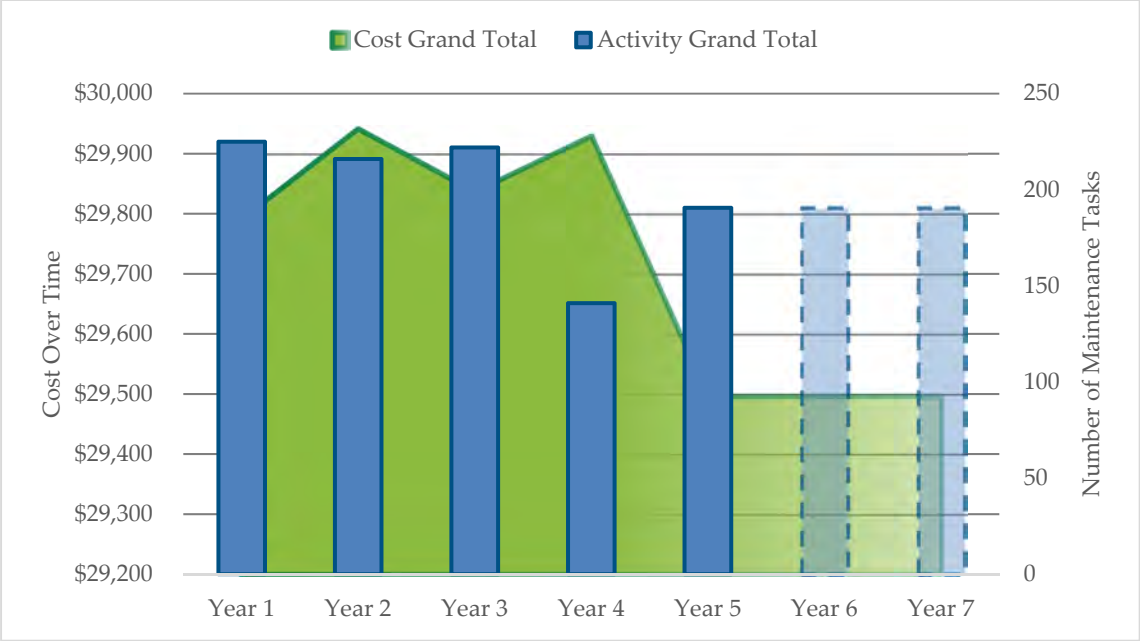


Figure 1. Five-year management program budget vs labor over time with projection into the future.

Recommended Maintenance Types

Tree Removal

Trees designated for removal have defects that cannot be cost-effectively or practically corrected. Most of the trees in this category have a large percentage of dead crown.

Total = 388 trees
High Priority = 10 trees
Moderate Priority = 378 trees

Priority Pruning

Priority pruning removes defects such as Dead and Dying Parts or Broken and/or Hanging Branches. Pruning the defected branch(es) can lower risk associated with the tree while promoting healthy growth.

Total = 60 trees
High Priority = 1 trees
Moderate Priority = 59 trees

Young Tree Training Cycle

Younger trees can have branch structures that lead to potential problems as the tree ages, requiring training to ensure healthy growth. Training is completed from the ground with a pole pruner or pruning shear.

Number in cycle each year = 25 trees, after new plantings have been installed

Tree Planting

Planting new trees in areas that have poor canopy continuity is important, as is planting trees where there is sparse canopy, to ensure that tree benefits are distributed evenly across county parks and trails.

Total stump replacement plantings = 27 trees
Total new plantings = 25 trees per year

Routine Tree Inspection

Routine inspections are essential to uncovering potential problems with trees and should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees.

Total = 1 day of Level 1 assessments each year

INTRODUCTION

Monroe County is home to more than 147,000 residents benefitting from park trees in their community. The county's urban forestry program manages all trees along greenways and throughout designated public parks. For five years, the county's staff in the Parks and Recreation Department have shown continued commitment to developing a thriving public parks tree resource.

The urban forestry program budget is funded by the county's Commissioners and Parks and Recreation board. Monroe County has an International Society of Arboriculture (ISA) Certified Arborist on staff and will soon be able to set goals and perform proactive maintenance using this *Parks Tree Resource Management Plan*. The county's urban forestry program is on its way to creating a sustainable and resilient public parks tree resource, and it is important to stay on track by consistently renewing program funding and routinely updating the tree inventory.

RECOMMENDED APPROACH TO TREE MANAGEMENT

An effective approach to tree resource management follows a proactive and systematic program that sets clear and realistic goals, prescribes future action, and periodically measures progress. A robust urban forestry program establishes tree maintenance priorities and utilizes modern tools such as a tree inventory accompanied by TreeKeeper® or other asset management software.

In December 2020, Monroe County worked with DRG to inventory its parks trees and develop this management plan. The plan analyzes the tree inventory and provides guidelines for a prioritized system of public parks tree management. The following tasks were completed:

- A limited inventory of trees meeting set criteria throughout greenway rights-of-way (ROW) and select park trails and structures.
- Analysis of tree inventory data.
- Development of a management plan that prioritizes the recommended tree maintenance.

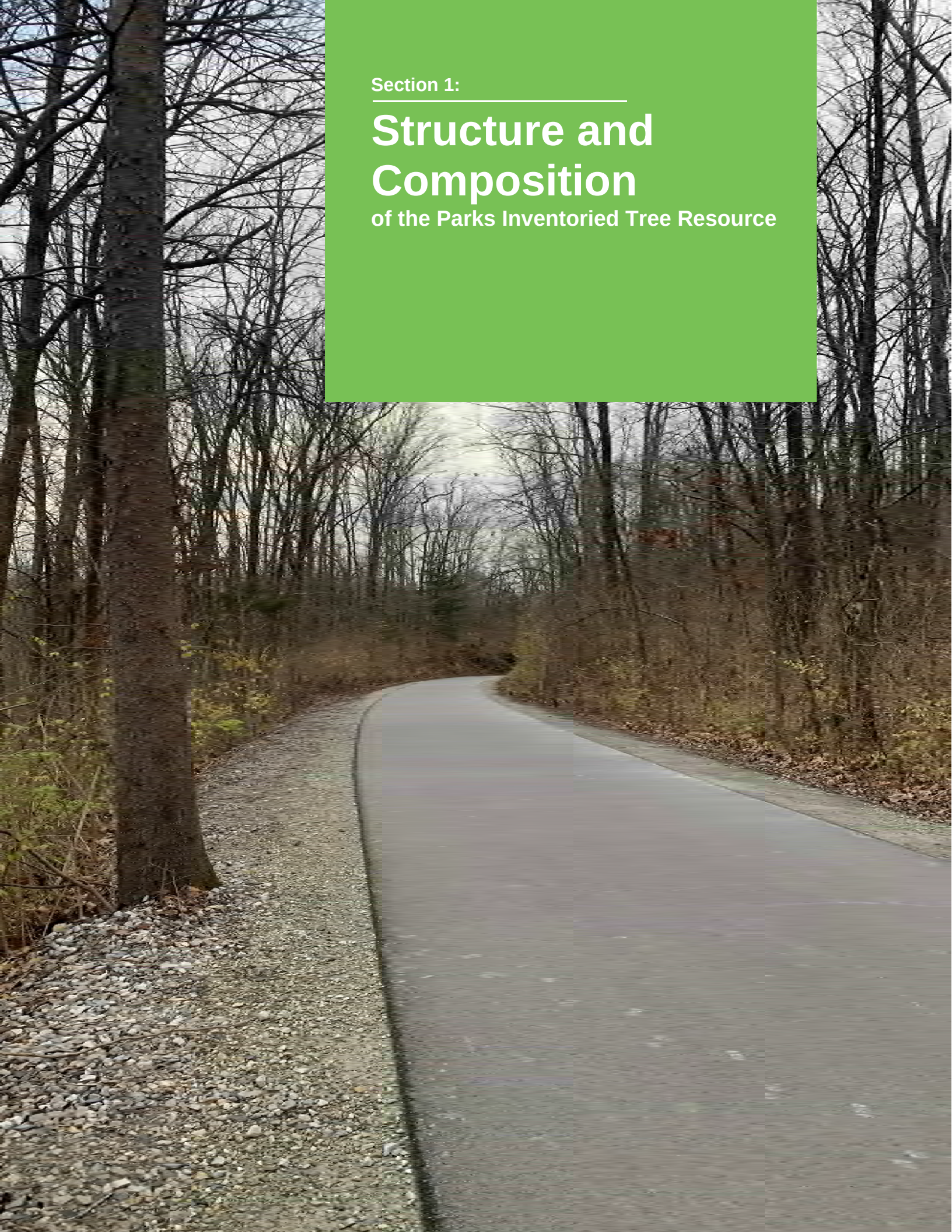
Consisting of three sections, this plan considers the health and safety of the inventoried tree population and provides a proactive program for managing the county's public parks tree resource.

- *Section 1: Structure and Composition of the Parks Inventoried Tree Resource* summarizes the inventory data with trends representing the current state of the inventoried high-risk trees.
- *Section 2: Functions and Benefits of the Parks Inventoried Tree Resource* summarizes the estimated value of benefits provided to the community by the inventoried population of trees' various functions.
- *Section 3: Recommended Management of the Parks Tree Resource* details a prioritized management system vs a proactive program and provides an estimated budget for recommended maintenance activities prioritized over a five-year period.

Section 1:

Structure and Composition

of the Parks Inventoried Tree Resource



SECTION 1: STRUCTURE AND COMPOSITION

In December 2020, DRG arborists collected trees throughout greenway rights-of-way (ROW) and select park trails and structures for a limited tree inventory contracted by Monroe County. A tree was inventoried if only it posed a significant or severe consequence and was more likely than not to fail within one year. Of the total 448 trees inventoried, 62% were collected along greenways, and the remaining 38% were collected along park trails and around structures. Figure 2 breaks down the total trees inventoried by location. See Appendix A for DRG's methodology for collecting site data.

Data collected was as follows: overall tree condition, most significant defect, diameter at 4.5 feet (DBH), if further inspection is needed, grow space type, if hardscape damage is present, land use type, if the tree is a multi-stem, if overhead utilities are present and conflict potential, park/trail/greenway name, primary maintenance need, relative location, risk rating, species identification, tag number, and X/Y coordinates. The focus of the inventory was to identify hazardous trees with significant or severe consequences of failure within one year of inventory completion.

Monroe County designated five project areas (Flatwoods Park, Karst Farm Greenway, Karst Farm Park, Limestone Greenway, and Will Detmer Park) for DRG to collect site data for the tree inventory.

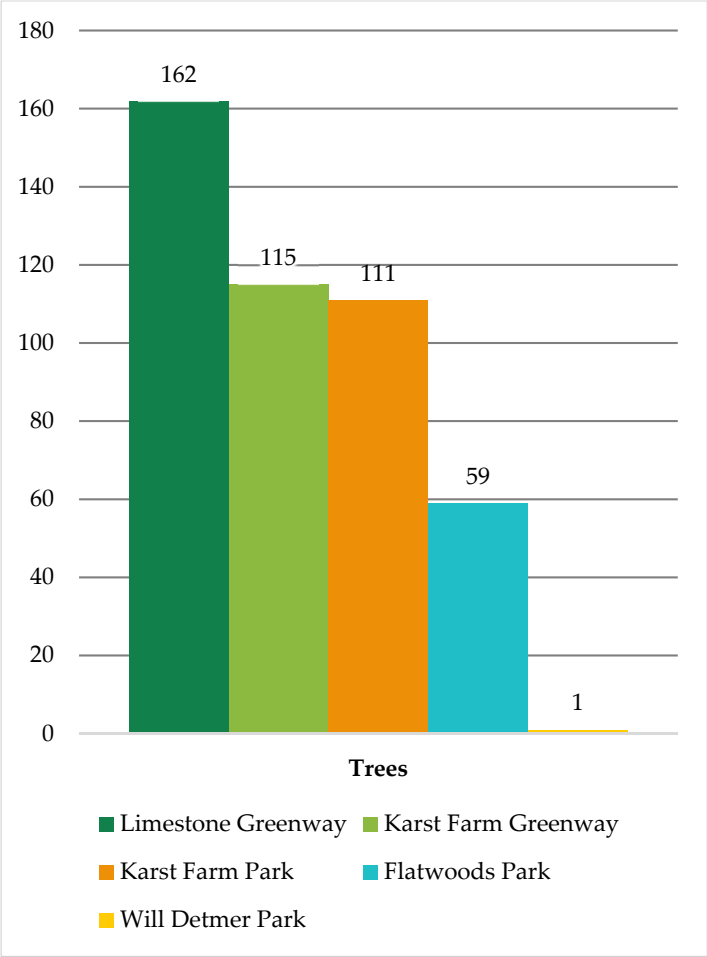


Figure 2. Number of inventoried trees by location.

SPECIES DISTRIBUTION

Figures 3, 4, 5, and 6 show Monroe County's distribution of most abundant tree species inventoried broken down by location. The inventory of Will Detmer Park, not displayed, contained a single silver maple (*Acer saccharinum*). Overall, ash (*Fraxinus* spp.) is the most abundant species throughout the entire inventory, and black cherry (*Prunus serotina*) is the next most abundant species.

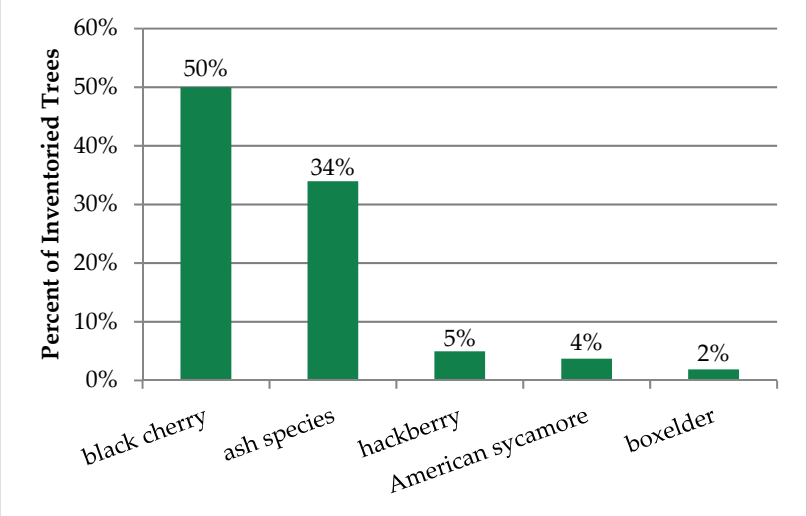


Figure 3. Species distribution of inventoried trees on Limestone Greenway.

Figure 3 shows that black cherry, at 50%, is the most abundant species on the Limestone Greenway, and ash species are the next most abundant species at 34%. No other species made up more than 6% of the Limestone Greenway inventory.

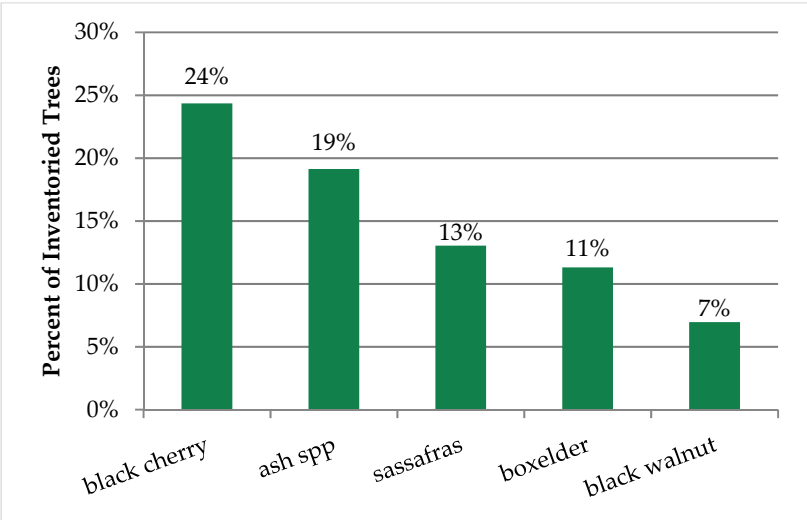


Figure 4. Species distribution of inventoried trees on Karst Farm Greenway.

RESILIENCE THROUGH DIVERSITY

The Dutch elm disease epidemic of the 1930s demonstrates a key historical lesson on the importance of diversity (Karnosky 1979). The disease killed millions of American elm trees, leaving behind enormous gaps in the urban canopy of many Midwestern and Northeastern communities. In the aftermath, ash trees became popular replacements and were heavily planted along city streets. History repeated itself in 2002 with the introduction of the emerald ash borer into America. This invasive beetle devastated ash tree populations across the Midwest. Other invasive pests spreading across the country threaten urban forests and it is vital that we learn from history and plant a wider variety of tree genera to develop a resilient public tree resource.

Ash trees in an urban forest killed by emerald ash borer.

USDA Forest Service (2017)

Figure 4 shows that black cherry, at 24%, is the most abundant species on the Karst Farm Greenway, and ash species are the next most abundant at 19%. No other species made up more than 14% of the Karst Farm Greenway inventory.

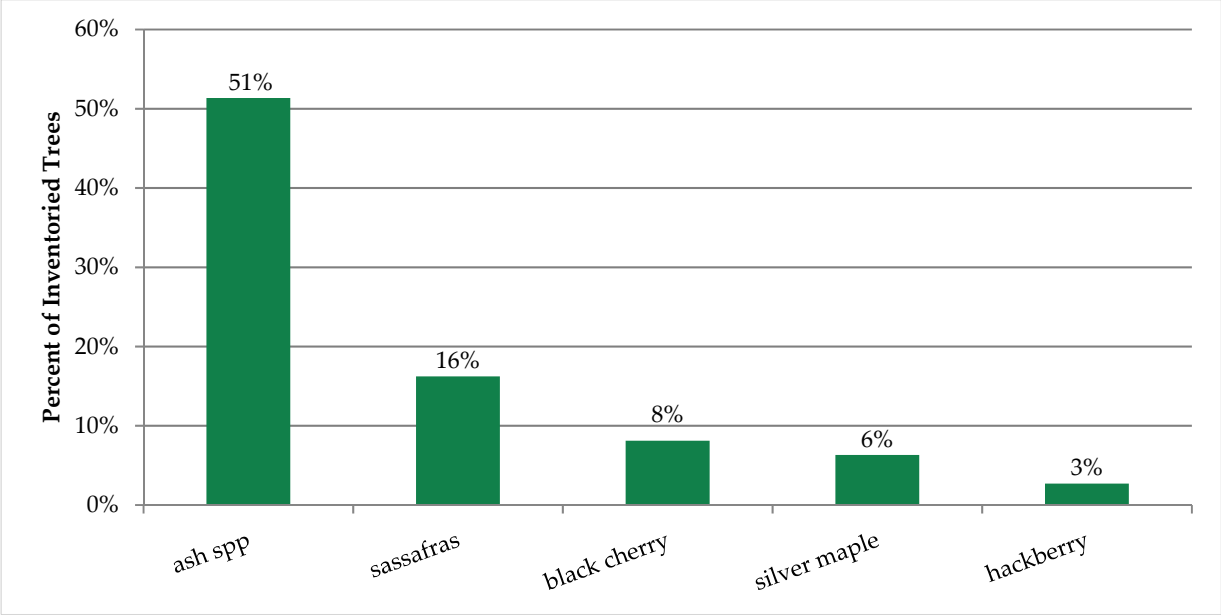


Figure 5. Species distribution of inventoried trees in Karst Farm Park.

Figure 5 shows that ash species, at 51%, are the most abundant in Karst Farm Park, and sassafras (*Sassafras albidum*) is the next most abundant species at 16%. No other species made up more than 9% of the Karst Farm Park inventory.

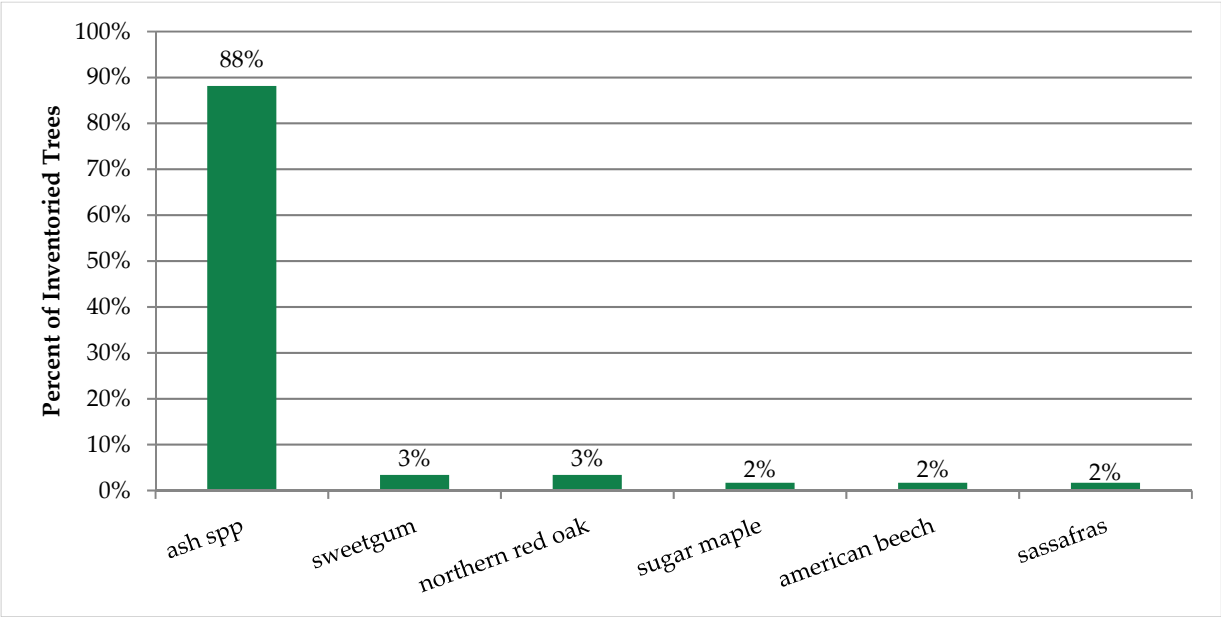


Figure 6. Species distribution of inventoried trees in Flatwoods Park.

Figure 6 shows that ash species are the most abundant species at 88% in Flatwoods Park. No other species made up more than 4% of the Flatwoods Park inventory.

Species Recommendations

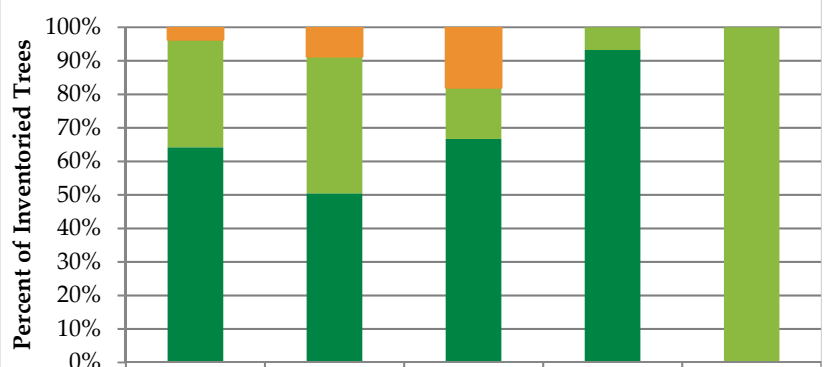
The 10-20-30 rule is a common standard for tree population distribution, in which a single species should compose no more than 10% of the tree population, a single genus no more than 20%, and a single family no more than 30% (Santamour 1990). However, this inventory focused on high-risk trees therefor this measurement is obsolete until a complete inventory of landscaped areas is collected and analyzed. DRG's recommendation is to inventory all manicured areas to gain a well-rounded understanding of the parks tree resource composition.

Conclusions that can be drawn up are related to problematic tree species. Ash species, black cherry, and silver maple were common denominators within the project areas. Emerald ash borer (EAB, *Agrilus planipennis*), an invasive pest that targets a single genus as its host, is the reason why ash species were inventoried most often. The reason for black cherry and silver maple being inventoried often is they resist decay poorly. For these reasons, Monroe County should use its resources to at a minimum inspect all ash species, black cherry, and silver maple on a routine basis, so affected trees can be quarantined to mitigate problems before to get too worse.

CONDITION

The condition of each inventoried tree was rated by an arborist as Good, Fair, Poor, or Dead. Several factors affecting condition were considered for each tree, including root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. Condition ratings were defined as:

- *Good*. A tree that shows no significant problems.
- *Fair*. A tree that has minor problems that may be corrected with time or corrective action.
- *Poor*. A tree that has significant problems that are irrecoverable.
- *Dead*. A tree that shows no sign of life.



	Limestone Greenway	Karst Farm Greenway	Karst Farm Park	Flatwoods Park	Will Detmer Park
Fair	4%	9%	18%	0%	0%
Poor	32%	41%	15%	7%	100%
Dead	64%	50%	67%	93%	0%

Figure 7. Condition of inventoried trees by location.

Figure 7 shows most of the inventoried trees were recorded in Poor or Dead condition, 27% and 65% overall, respectively. No trees were recorded in Good condition. This was to be expected because DRG was to only inventory trees of significant concern.

Condition Recommendations

Dead trees should be removed as soon as possible because the health of these trees is unlikely to recover even with increased care and present a risk.

Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will likely need removed but few could receive corrective pruning to improve their safety or reduce their risk and prolong their benefits. Poor condition trees should be removed or monitored (annually at a minimum) for worsening conditions. The inventory recommends 96 removals of 121 trees categorized as Poor condition.

Fair condition may benefit from crown cleaning and structural pruning to improve their health over time. Pruning should follow *ANSI A300 (Part 1)* guidelines.

RELATIVE AGE DISTRIBUTION

Analysis of a tree population's relative age distribution is performed by assigning age classes to the size classes of inventoried trees, offering insight into the maintenance needs of Monroe County's tree resource. The inventoried trees are grouped into the following relative age classes:

- Young trees (0–8 inches diameter at breast height (DBH))
- Established trees (9–17 inches DBH)
- Maturing trees (18–24 inches DBH)
- Mature trees (greater than 24 inches DBH)

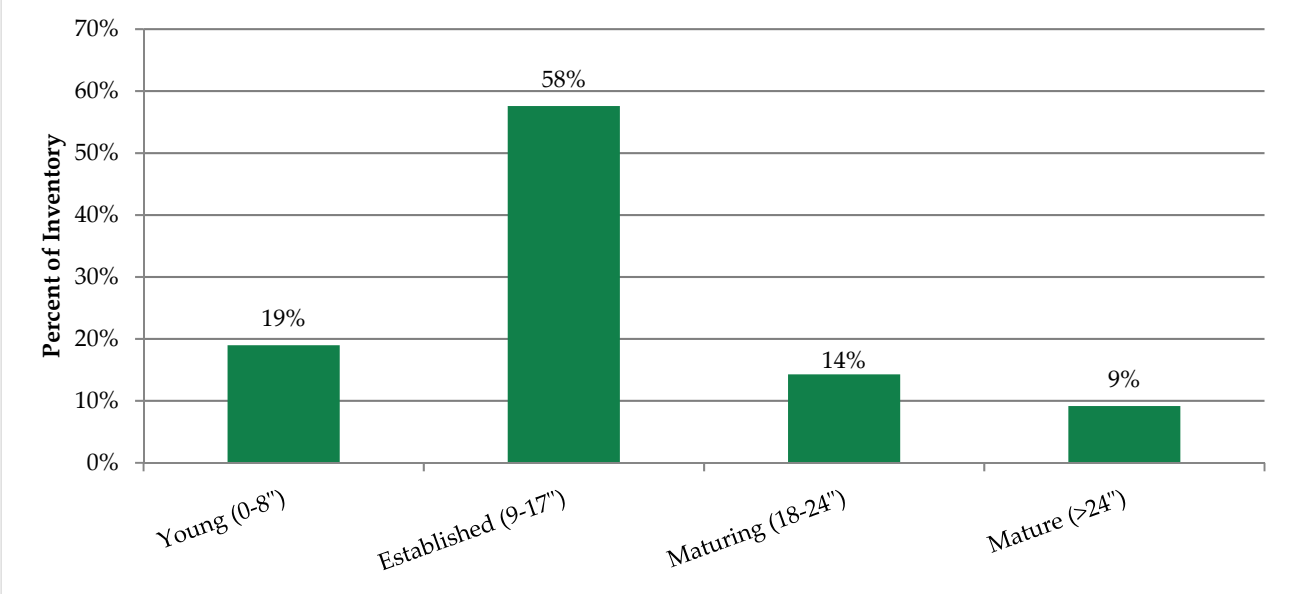


Figure 8. Relative age distribution of inventoried trees.

Figure 8 illustrates Monroe County's relative age distribution of the inventoried tree population. This shows that the composition of the inventoried trees is weighted towards established (58%) trees compared to younger (19%), maturing (14%), and mature (9%) trees.

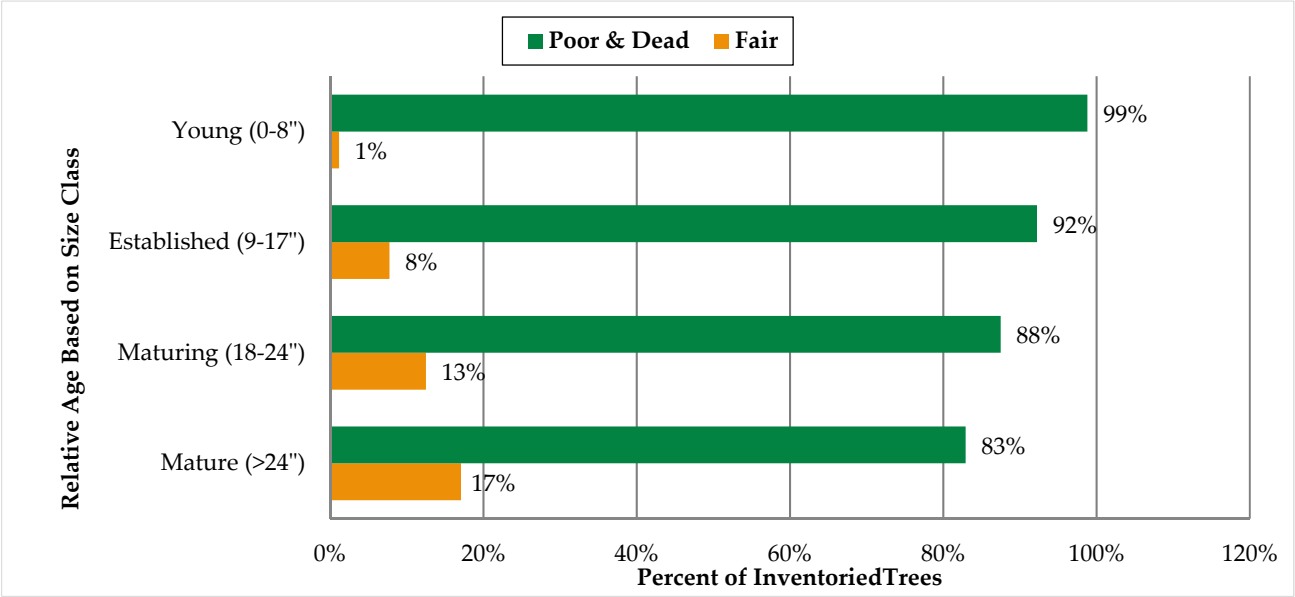


Figure 9. Condition of inventoried trees by relative age class.

Figure 9 cross analyzes the condition of the inventoried tree resource with its relative age distribution. Only high-risk trees were included in the inventory so conditions trend towards the poorer end of the spectrum.

Percentages of Poor and Dead trees decline as size class increases across all size classes. Almost half of Poor and Dead trees at ages young, established, and maturing are ash species. This suggests that most ash species are less than 25 inches DBH and the occurrence of Poor and Dead trees among all species is highest at maturity.

Percentages of Fair trees increase as size class increases across all size classes. The older trees are the more high-risk problems may occur.

Relative Age Recommendations

DRG recommends that Monroe County implement a risk-based maintenance program to conserve tree benefits yet monitor safety of the greenway and trail systems and other frequented areas of the parks. Additionally, invasive insects and pests can cause havoc if not closely monitored and managed early. Prioritizing routine inspections with specific focus on problematic species or invasive pest hosts will protect trees from unnecessary removal and prevent them from succumbing to treatable defects.

DRG also recommends that Monroe County stimulate growth of native understory trees and other beneficial vegetation to help replace gaps in the canopy. Much of the trail side edges are natural wooded areas. The removal of trees, more specifically large canopy trees, will create an opportunity for invasive vegetation. Invasive vegetation like honeysuckle (*Lonicera* spp.) and multiflora rose (*Rosa multiflora*) are present along much of the trail system. The space and added sunlight from removed trees will create more opportunity for invasive growth. Monroe County should closely monitor the size of canopy disturbance created by tree removal and control invasive vegetation to promote new, native tree canopy.

DEFECT OBSERVATIONS

For each tree inventoried, DRG assessed conditions indicating the presence of structural defects and recorded the most significant structural defect.

Table 1. Tree defect categories recorded during the inventory.

Defects	Trees	Percent of Trees
Branch Attachment	0	0%
Broken and/or Hanging Branches	1	0%
Cracks	0	0%
Dead and Dying Branches	74	17%
Decay or Cavity	51	11%
Root Problems	5	1%
Tree Architecture	3	1%
Trunk Condition	23	5%
None	291	65%
Total	**448**	**100%**

The two most frequently recorded defect categories were Dead & Dying Branches and Decay or Cavity at 17% and 11% of inventoried trees, respectively (Table 1). Of the 74 trees with Dead & Dying Branches, 51 were in the young or established age classes. Of the 51 trees with Decay or Cavity, 30 were in the young or established age classes. Fair condition trees were observed having a significant defect at a rate 23% (36 Fair condition trees of 157 trees with a recorded defect) for mostly Broken and/or Hanging Branches and Dead & Dying Branches.

Defect Observation Recommendations

Many defects such as Broken and/or Hanging Branches and Dead and Dying Branches can often be pruned away while improving the overall health of the tree. Defects such as Decay or Cavity, Trunk Condition, and Root Problems are often irrecoverable from and result in the tree needing to be removed. DRG recommended primary maintenance based on the defect location, size of defect, and tree health after possible non-removal maintenance is completed. If the tree is still deemed to be in Poor condition after hypothetical maintenance, then removal is the recommended maintenance.

INFRASTRUCTURE CONFLICTS

Existing or possible conflicts between trees and infrastructure recorded during the inventory include:

- *Overhead Utilities*—The presence of overhead utility lines above a tree or planting site was noted; it is important to consider these data when planning pruning activities and selecting tree species for planting.
- *Hardscape Damage*—Tree roots can adversely impact hardscape such as curbs and sidewalks, causing these features to lift and crack. This data should be used to schedule pruning and plan repairs to damaged infrastructure. To limit hardscape damage caused by trees, trees should only be planted in growing spaces where adequate above ground and below ground space is provided.

Only three trees were recorded with an infrastructure conflict. All of those were noted due to overhead utilities being present but not conflicting.

Infrastructure Recommendations

Planting considerations should focus on the manicured areas of Monroe County property. Natural areas will regrow themselves through seed banks and understory trees already present on site. Planting only small-growing trees within 20 feet of overhead utilities, medium-size trees within 20–40 feet, and large-growing trees outside 40 feet will help improve future tree conditions, minimize future utility line conflicts, and reduce the costs of maintaining trees under utility lines.

When planting around hardscape, it is important to give the tree enough growing room above ground. Guidelines for planting trees among hardscape features are as follows: give small-growing trees 4–5 feet, medium-growing trees 6–7 feet, and large-growing trees 8 feet or more between hardscape features. In most cases, this will allow for the spread of a tree's trunk taper, root collar, and immediate larger-diameter structural roots. The inventory concentrated on natural areas resulting in few conflicts being found.

GROWING SPACE

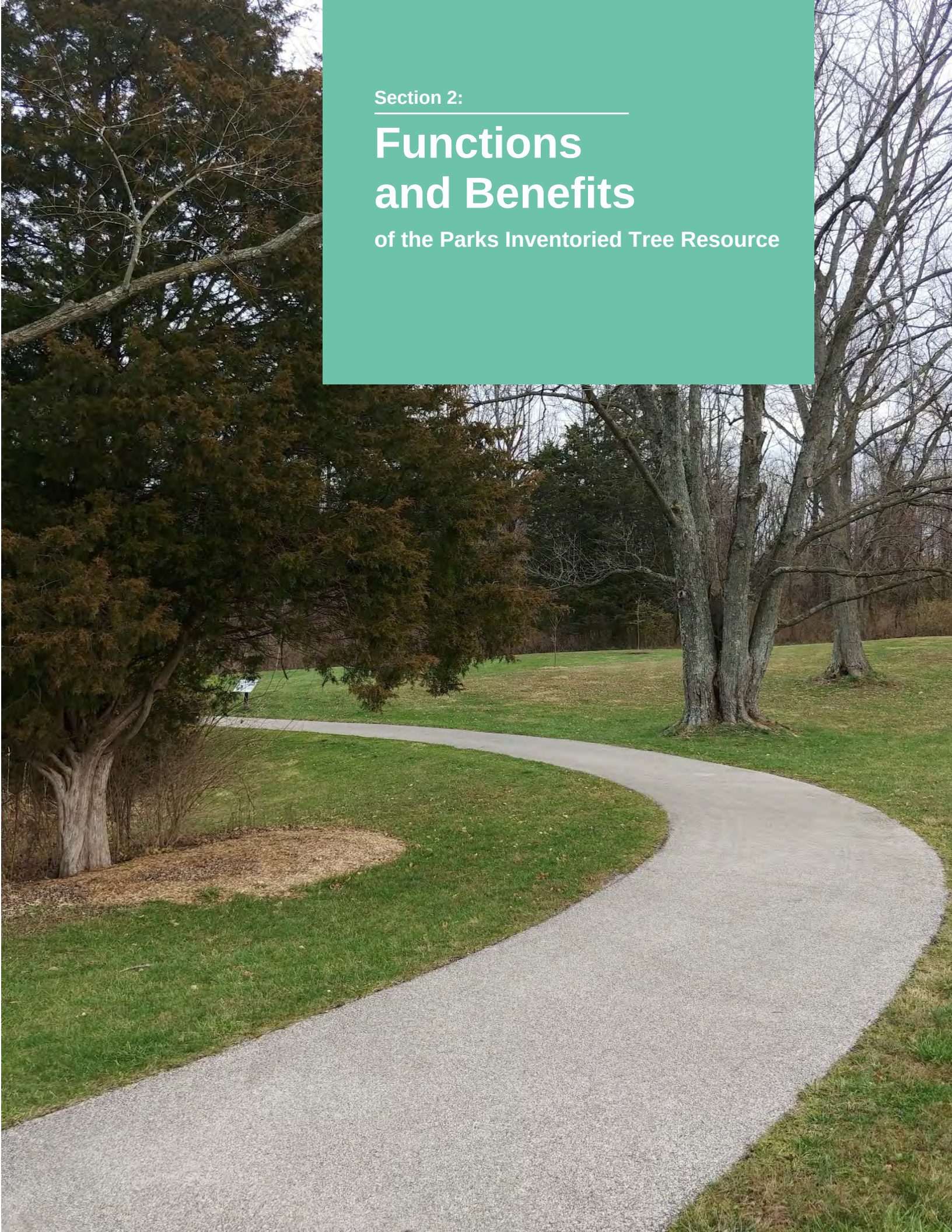
Information about the type of the growing space was recorded. Growing space types are categorized as follows:

- *Island*—surrounded by pavement or hardscape (for example, parking lot divider).
- *Median*—located between opposing lanes of traffic.
- *Open/Restricted*—open sites with restricted growing space on two or three sides.
- *Open/Unrestricted*—open sites with unrestricted growing space on at least three sides.
- *Raised Planter*—in an above-grade or elevated planter.
- *Tree Lawn/Parkway*—located between the street curb and the public sidewalk.
- *Unmaintained*—located in areas that do not appear to be regularly maintained.
- *Well/Pit*—at grade level and completely surrounded by sidewalk.

The majority (90%) of trees were in unmaintained areas as the inventory was mostly greenway and trail side edges with natural or non-manicured areas.

Growing Space Recommendations

The useful life of a public parks tree ends when the cost of maintenance exceeds the value contributed by the tree. This can be due to increased maintenance required by a tree in decline, or it can be due to the costs of repairing damage caused by the tree's presence in a restricted site. To prolong the useful life of public parks trees, small-growing tree species should be planted in green spaces 4–5 feet wide, medium-size tree species in green spaces 6–7 feet wide, and large-growing tree species in green spaces at least 8 feet wide. Parks and greenways mainly have large open green spaces with most conflicts coming from other already established trees or manmade structures. In areas away from structures, it is recommended that small-growing tree species be planted 20 feet from other trees, medium-sized tree species be 30 feet away from other trees, and large-growing tree species be 40 feet away from other trees. Having specifications for planting area allows for beneficial among of soil volume per tree and tree canopies to not be over-crowded by each other.



Section 2:

Functions and Benefits

of the Parks Inventoried Tree Resource

SECTION 2: FUNCTIONS AND BENEFITS

Trees occupy a vital role in the urban environment by providing of a wide array of economic, environmental, and social benefits far exceeding the investments in planting, maintaining, and removing them. Trees reduce air pollution, improve public health outcomes, reduce stormwater runoff, sequester and store carbon, reduce energy use, and increase property value. Using advanced analytics, such as i-Tree Eco and other models in the i-Tree software suite, understanding the importance of trees to a community continues to expand. Modern tools and computer models are providing a way to estimate monetary values of the various benefits provided by a public tree resource. See Appendix B for i-Tree Eco methodology and the USB drive that accompanied this *Parks Tree Resource Management Plan* for the i-Tree Eco analysis report and project file.

Environmental Benefits

- Trees decrease energy consumption and moderate local climates by providing shade and acting as windbreaks.
- Trees act as mini reservoirs, helping to slow and reduce the amount of stormwater runoff that reaches storm drains, rivers, and lakes. One hundred mature tree crowns intercept roughly 100,000 gallons of rainfall per year (U.S. Forest Service 2003a).
- Trees help reduce noise levels, cleanse atmospheric pollutants, produce oxygen, and absorb carbon dioxide.
- Trees can reduce street-level air pollution by up to 60% (Coder 1996). Lovasi (2008) suggested that children who live on tree-lined streets have lower rates of asthma.
- Trees stabilize soil and provide a habitat for wildlife.

Economic Benefits

- Trees in a yard or neighborhood increase residential property values by an average of 7%.
- Commercial property rental rates are 7% higher when trees are on the property (Wolf 2007).
- Trees moderate temperatures in the summer and winter, saving on heating and cooling expenses (North Carolina State University 2012, Heisler 1986).
- On average, consumers will pay about 11% more for goods in landscaped areas, with this figure being as high as 50% for convenience goods (Wolf 1998b, Wolf 1999, and Wolf 2003).
- Consumers also feel that the quality of products is better in business districts surrounded by trees than those considered barren (Wolf 1998b).
- The quality of landscaping along the routes leading to business districts had a positive influence on consumers' perceptions of the area (Wolf 2000).

Social Benefits

- Tree-lined streets are safer; traffic speeds and the amount of stress drivers feel are reduced, which likely reduces road rage/aggressive driving (Wolf 1998a, Kuo and Sullivan 2001a).
- Chicago apartment buildings with medium amounts of greenery had 42% fewer crimes than those without any trees (Kuo and Sullivan 2001b).
- Chicago apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Employees who see trees from their desks experience 23% less sick time and report greater job satisfaction than those who do not (Wolf 1998a).
- Hospital patients recovering from surgery who had a view of a grove of trees through their windows required fewer pain relievers, experienced fewer complications, and left the hospital sooner than similar patients who had a view of a brick wall (Ulrich 1984, 1986).

i-TREE ECO ANALYSIS

i-Tree Eco utilizes tree inventory data along with local air pollution and meteorological data to quantify the functional benefits of a community's tree resource. By framing trees and their benefits in dollars saved per year, i-Tree Eco helps a community understand trees as both a natural resource and an economic investment. Knowledge of the composition, functions, and monetary value of trees helps inform planning and management decisions, assists in understanding the impact of those decisions on human health and environmental quality, and aids communities in advocating for the necessary funding to manage their vested interest in the public tree resource appropriately.

ANNUAL RETURN ON INVESTMENT FROM THE INVENTORIED POPULATION

The i-Tree Eco analysis of Monroe County's inventoried tree resource quantified the functional benefits of three critical ecosystem services that they provide: air pollution removal, carbon sequestration, and avoided surface runoff. Figure 10 displays the economic values of those ecosystem services provided by only living inventoried trees (Poor and Fair condition). Of the 448 trees inventoried, only 157 trees provide Monroe County with an estimated $619 of annual tree benefit. Also, a major account of public benefit that is not provided by estimates is human health contributions. Trees along greenways and trails and withing parks provide users a reduced amount of stress and encourage healthy activity (Wolf 2017).

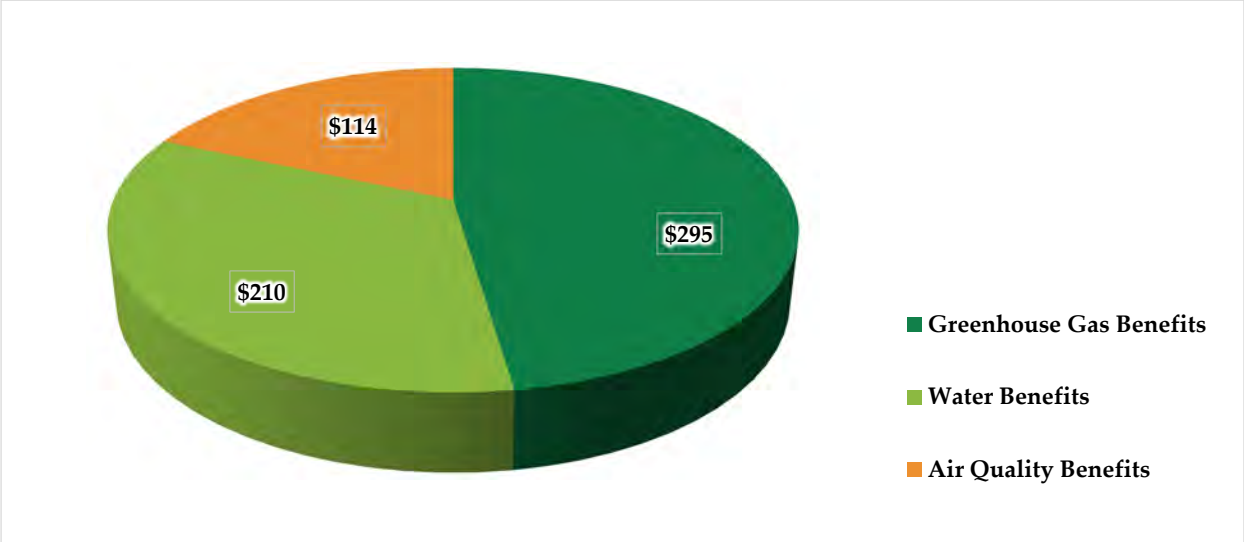


Figure 10. Estimated value of the benefits provided by all inventoried trees.

Urban environments have unique challenges that make the estimated $619 of functional benefits provided by Monroe County's inventoried tree population an essential asset to the county. The value of this small population that is mostly Poor condition is great. Airborne pollutants (62 pounds) are removed by the few of Monroe County's inventoried tree resource at an estimated $114 annually. Avoided stormwater runoff (23,481 gallons) reduces the risk of flooding, both of which impact people, property, and the environment, by the few of Monroe County's inventoried tree resource valued at an estimated $210 annually. Carbon dioxide (CO_2) also impacts people, property, and the environment as the primary greenhouse gas driving climate change. Carbon is sequestered from the air (3,460 pounds) by the few of Monroe County's inventoried tree resource valued at an estimated $295 annually.

It is critical to promote species diversity with future plantings and natural area management to minimize susceptibility to potential threats, and to plant large-statured broadleaf tree species wherever possible to maximize potential environmental and economic benefits.

SEQUESTERING AND STORING CARBON

Trees are carbon sinks. While carbon is emitted from cars and smokestacks, carbon is absorbed into trees during photosynthesis and stored in their tissue as they grow. The i-Tree Eco model estimates both the carbon sequestered each year and total carbon stored. Monroe County's inventoried trees have stored 412,180 pounds of carbon, which is all the carbon each tree has amassed throughout their lifetimes and is valued at $35,149. Black cherry and silver maple store the most carbon: 1,656 pounds per tree and 4,320 pounds per tree, respectively. Both species also sequester the most carbon: 12 pounds per tree per year and 10 pounds per tree per year, respectively.

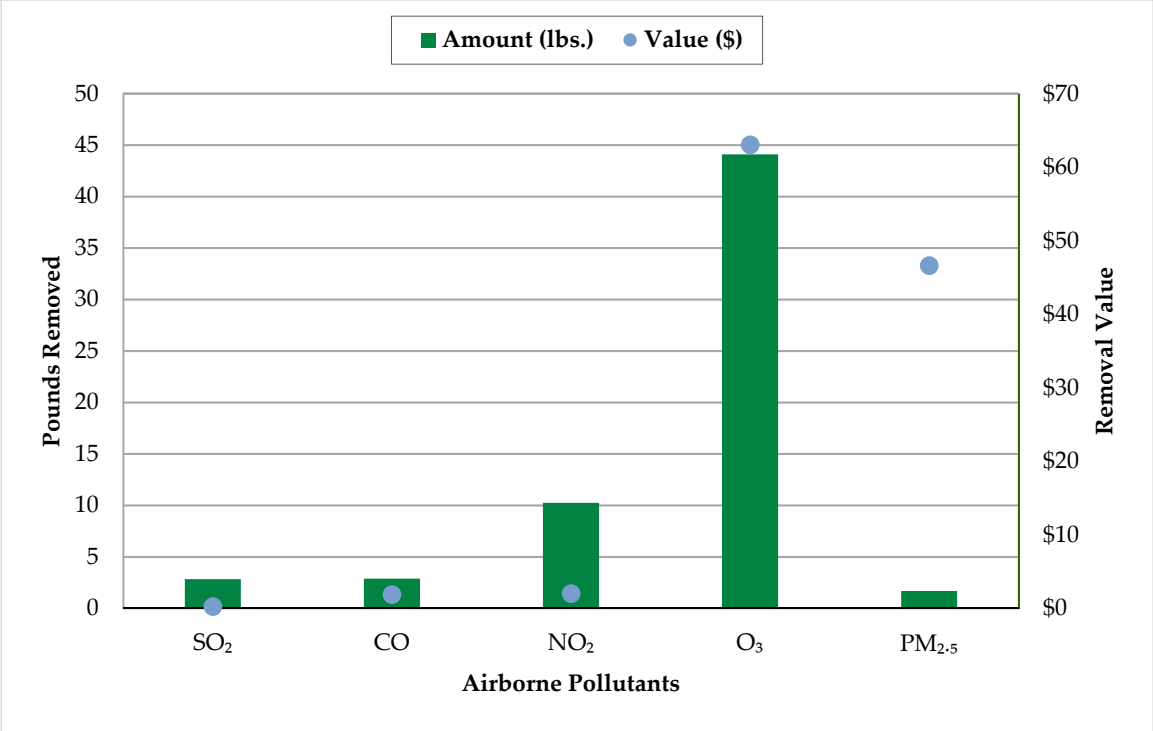


Figure 11. Estimated value of air pollutants removed provided by all inventoried trees.

Table 2. Summary of benefits provided by identifiable inventoried tree species representing 1% or more of the population.

Most Common Trees Inventoried		Count	Percent of Total	Benefits Provided by Inventoried Trees			
				CO_2 Stored	CO_2 Sequestered**	Avoided Runoff	Air Pollution Removed**
Common Name	Botanical Name		%	Pounds	Pounds/year	Gallons/year	Pounds/year
black cherry	*Prunus serotina*	118	26%	195,360	1,460	6,061	20
ash species*	*Fraxinus* spp.	101	23%	0	0	0	0
white ash	*Fraxinus americana*	58	13%	36,640	80	472	0
sassafras	*Sassafrass albidum*	34	8%	13,540	280	1,637	0
green ash	*Fraxinus pennsylvanica*	27	6%	4,280	60	757	0
boxelder	*Acer negundo*	16	4%	5,960	100	681	0
northern hackberry	*Celtis occidentalis*	12	3%	8,720	140	1,223	0
silver maple	*Acer saccharinum*	10	2%	43,200	320	3,132	0
black walnut	*Juglans nigra*	10	2%	14,820	200	2,224	0
American sycamore	*Platanus occidentalis*	10	2%	25,680	180	2,269	0
sugar maple	*Acer saccharum*	9	2%	22,960	260	1,745	0
American elm	*Ulmus americana*	8	2%	1,920	0	51	0
black locust	*Robinia pseudoacacia*	6	1%	5,160	80	557	0
northern red oak	*Quercus rubra*	4	1%	19,940	180	888	0
tulip tree	*Liriodendron tulipifera*	3	1%	8,140	80	1,128	0
All Other Trees Inventoried		11	4%	5,860	80	656	0
Total	**24 species**	**437**	**100%**	**412,180**	**3,500**	**23,481**	**20**

*Ash species represents only dead trees which provide no benefits but were a significant portion of the inventory.

**The other zeroes are due to the trees providing negligible amounts of benefits.

MANAGING STORMWATER

Trees intercept rainfall with their leaves and branches, helping lower stormwater management costs by avoiding runoff. The inventoried trees in Monroe County avoid 23,481 gallons of runoff annually. Avoided runoff accounts for 34% of the annual functional benefits provided by Monroe County's inventoried public parks tree resource.

Of all species inventoried, black cherry contributed the most annual stormwater benefits. The black cherry population, most abundant species (26% of inventoried trees), avoided 6,061 gallons of runoff.

On a per-tree basis, large-mature trees with leafy canopies provided the most functional benefits. There are 2 more northern hackberry (*Celtis occidentalis*) trees than silver maple trees inventoried. Silver maple avoided 3,132 gallons of runoff and northern hackberry avoided 1,223 gallons of runoff. Silver maple (202 cumulative inches of DBH) is providing more than twice as much value compared to northern hackberry (119 cumulative inches of DBH), despite having a population size difference of only 2 trees. This illustrates how large-mature trees with wide canopies provide significantly greater benefits.

IMPROVING AIR QUALITY

The inventoried tree population annually removes 20 pounds of air pollutants, including sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and particulate matter ($PM_{2.5}$). The i-Tree Eco model estimated the value of this benefit at $114, which is 18% of the value of all annual benefits. As shown in Figure 11, a small reduction of $PM_{2.5}$ is more valuable than any of the other pollutants removed. The tree species that provided the highest annual air quality benefits was black cherry which removed 20 pounds of pollutants per tree per year.

CANOPY FUNCTIONS

Trees provide many functions and benefits all at once simply by existing, such as:

- Catching rainfall in their crown so it drips to the ground with less of an impact or flows down their trunk.
- Helping stormwater soak into the ground by slowing down runoff.
- Creating more pore space in the soil with their roots, helping stormwater to move through the ground.
- Cooling the surrounding landscape by casting shade with their canopy and releasing water from their leaves.
- Catching airborne pollutants on their leaves and absorbing them with their roots when they wash off in the rain.
- Transforming some pollutants into less harmful substances and preventing other pollutants from forming.

Section 3:

Recommended Management

of the Parks Tree Resource

SECTION 3: RECOMMENDED MANAGEMENT

During the inventory, both a risk rating and a recommended maintenance activity were assigned to each tree. DRG recommends prioritizing and completing each tree's recommended maintenance activity based on the assigned risk rating. This five-year management program takes a multi-faceted and proactive approach to parks tree resource management.

High Priority

- All High Priority tree removals and pruning should be completed as soon as possible, because these trees have significant defects that will become more severe over time.

Moderate Priority

- Moderate Priority tree removals and pruning should start after High Priority tree maintenance has been completed.

Low Priority

- Low Priority tree maintenance should be performed after all High and Moderate Priority maintenance has been completed.

Stump Removal

- Stump removals should be performed either when a tree is removed or before a planting season begins, so planting sites become vacant for replacement trees.

Routine Inspection

- Routine Inspection from a drive-by perspective is important for detecting major defects before they worsen, and a walk-around perspective is important for updating inventory data.

Young Tree Training

- Young Tree Training Cycles improve tree structure so defects do not worsen and become more costly to correct as they grow, and should begin as soon as possible.

Routine Pruning

- Routine Pruning Cycles correct defects before they worsen, which is crucial for the better ment of the overall tree resource condition over the long-term.

Replace Trees

- Removed trees should be replaced so there is net a loss of the tree resource, and new trees should enter the Young Tree Training Cycle immediately.

Tree Planting

- Planting new trees is important for increasing population size and urban canopy, but can wait until higher priority maintenance is complete or at least in progress.

RISK MANAGEMENT AND RECOMMENDED MAINTENANCE

Although tree removal is usually considered a last resort and may sometimes create a reaction from the community, there are circumstances in which removal is necessary. Trees fail from natural causes such as diseases, insects, and weather conditions, as well as from physical injury due to vehicles, vandalism, and root disturbance. DRG recommends that trees be removed when corrective pruning will not adequately mitigate risk or when correcting problems would be cost-prohibitive. Tree maintenance activities should be prioritized and completed based on the risk rating assigned to each tree during the inventory.

Diseased and nuisance trees should be removed when their defects cannot be corrected through pruning or other maintenance practices. Even though large short-term expenditures may be required, it is important to secure the funding needed to complete priority tree removals. Expedient removal reduces risk and promotes public safety. Figures 12 and 13 present tree pruning and tree removals by risk rating and diameter size class. Tables 3 and 4 present tree pruning and tree removals by risk rating and site location. The following sections briefly summarize the recommended pruning and removals identified during the inventory as well as recommended maintenance for each risk rating category.

EXTREME AND HIGH PRIORITY RECOMMENDED MAINTENANCE

Pruning or removing Extreme and High Risk trees is strongly recommended to be prioritized and completed as soon as possible. In general, maintenance activities should be completed first for the largest diameter trees (>25″) that pose the greatest risk. Once addressed, recommended tree maintenance activities should be completed for smaller diameter trees (<25″) that pose the greatest risk. Addressing Extreme and High Risk trees in a timely and proactive manner often requires significant resources to be secured and allocated. Performing this work expediently will mitigate risk, improve public safety, and reduce long-term costs.

High Priority Pruning Recommendations

Extreme and High Risk trees should be pruned immediately based on assigned risk rating, which generally requires removing defects such as dead and dying parts, broken and/or hanging branches, and missing or decayed wood that may be present in tree crowns, even when most of the tree is sound. In these cases, when pruning the defected branch(es) can correct the problem, risk associated with the tree is reduced while promoting healthy growth.

The inventory identified 1 High Risk tree and 0 Extreme Risk trees recommended for pruning. The diameter size class for the tree recommended high-priority and mitigation activity pruning was 25–30 inches DBH. This maintenance should be performed immediately based on assigned risk rating and may be performed concurrently with other high priority removals. Table 3 shows that the 1 High Risk tree is located along the Karst Farm Greenway.

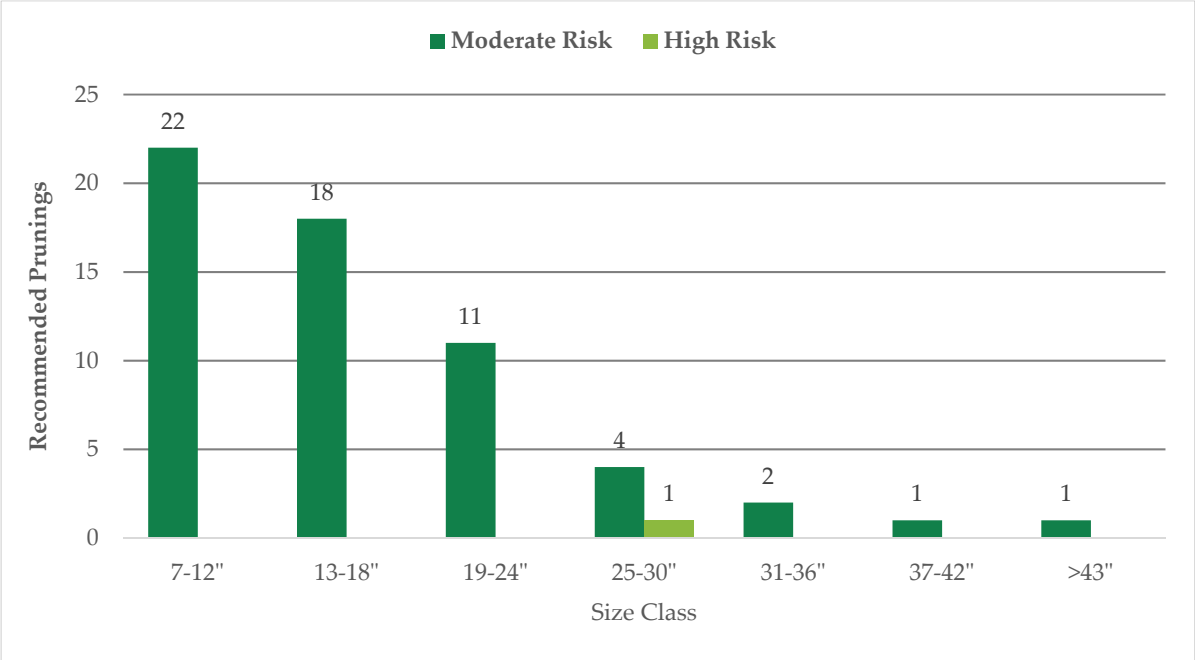


Figure 12. Recommended pruning by size class and risk rating.

Table 3. Recommended pruning by site location and risk rating.

Greenway/Park Name	High Risk	Moderate Risk
Limestone Greenway	0	17
Karst Farm Greenway	1	20
Karst Farm Park	0	21
Flatwoods Park	0	1
Will Detmer Park	0	0
Total	**1**	**59**

High Priority Removal Recommendations

Extreme and High Risk trees should be removed immediately based on assigned risk rating, which generally involved defects that compromise the entire tree such as cracks, decay or cavity, and root problems. DRG recommends that trees be removed when pruning will not correct their defects, eliminate the risks that their defects cause, or when corrective pruning would be cost-prohibitive. These trees should be removed immediately based on their risk rating and size class.

The inventory identified 10 High Risk and 0 Extreme Risk trees recommended for removal. The diameter size classes for High Risk trees ranged between 4–6 inches DBH and 25–30 inches DBH. In Table 4, we see that 8 of these High Risk trees are along the Limestone Greenway, 1 is along the Karst Farm Greenway, and 1 tree is in Karst Farm Park.

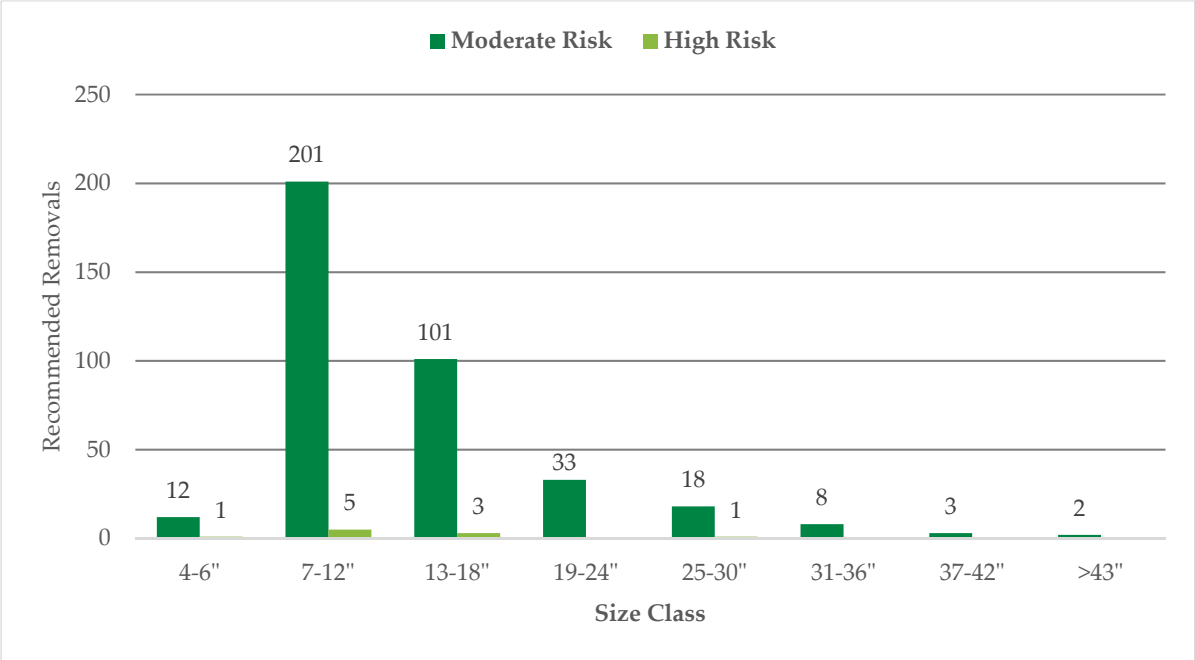


Figure 13. Recommended removals by size class and risk rating.

Table 4. Recommended removals by site location and risk rating.

Greenway/Park Name	High Risk	Moderate Risk
Limestone Greenway	8	137
Karst Farm Greenway	1	93
Karst Farm Park	1	89
Flatwoods Park	0	58
Will Detmer Park	0	1
Total	**10**	**378**

MODERATE PRIORITY RECOMMENDED MAINTENANCE

Pruning or removing Moderate and Low Risk trees are generally the next priorities for maintenance activities. For efficiency, a Moderate and Low Risk tree may be addressed at the same time when providing the same needed maintenance to an adjacent higher risk tree.

Moderate Priority Pruning Recommendations

Pruning of Moderate and Low Risk trees should be performed after all high priority recommended maintenance is complete.

The inventory identified 60 Moderate Risk and 0 Low Risk trees recommended for pruning. The diameter size classes for Moderate Risk trees ranged between 7–12 inches DBH and >43 inches DBH.

Table 3 shows that these trees were evenly split between Limestone Greenway, Karst Farm Greenway, and Karst Farm Park with 17, 20, and 21, respectively. One tree is in Flatwoods Park. If corrective pruning cannot correct a tree's defects and/or adequately mitigate risk, then the tree should be removed.

Moderate Priority Removal Recommendations

Removal of Moderate and Low Risk trees should be performed after all high priority recommended maintenance is complete.

The inventory identified 378 Moderate Risk and 0 Low Risk trees recommended for removal. Most Moderate Risk trees recommended for removal were smaller than 25 inches DBH. A total of 31 trees larger than 25 inches DBH were recommended for removal. These trees should be removed as soon as possible after all higher priority removals have been completed.

As outlined in Table 4, 137 Moderate Risk Removals are along the Limestone Greenway. Karst Farm Greenway, Karst Farm Park, and Flatwoods Park have 93, 89, and 58 Moderate Risk trees. There is 1Moderate Risk Removal tree of 54 inches DBH in Will Detmer Park.

FURTHER INSPECTION

In the ANSI A300 system, there are three levels of risk assessment. Each level is built on the one before it. The lowest level is designed to be a cost-effective approach to quickly identifying tree risk concerns; whereas the highest level is intended to provide in-depth information to make a more informed decision about a tree. These levels are:

- **Level 1** inspection is defined as a Limited Visual assessment, which is often conducted as a walk-by or windshield survey designed to identify obvious defects or specified conditions. This is the level of assessment DRG was tasked to abide by for the initial Monroe County Parks tree inventory.
- **Level 2** inspection is defined as a Basic assessment and is a detailed, 360-degree visual inspection of a tree and its surrounding site, and a synthesis of the information collected.
- **Level 3** inspection is an Advanced assessment and is performed to provide detailed information about specific tree parts, defects, targets, or site conditions. A Level 3 inspection may use specialized tools or require historical site assessment.

The Further Inspection data field indicates whether a tree requires additional and/or frequent future inspections to assess and/or monitor conditions that may cause it to become a risk to people, property, or other trees. Further Inspections are beyond the scope of a standard tree inventory, and are classified as one of the following:

- **Recent Damage** (e.g., a healthy tree that has been impacted by recent construction, weather, or other damage).
- **Advanced Risk Assessment** (e.g., a tree with a defect requiring additional or specialized equipment for investigation).
- **Insect/Disease Monitoring** (e.g., a tree that appears to have an emerging insect or disease problem).
- No further inspection required.

Trees with a Further Inspection requirement should be assessed by an ISA Certified Arborist as soon as possible, because the longer serious defects are left unaddressed, the greater a risk that a tree becomes. For the same reason, the maintenance that the arborist recommends should be performed as soon as possible to minimize risk.

Further Inspection Recommendations

The inventory found 6 trees requiring insect and disease monitoring. Species included ash species and black cherry. No other type of further inspection was recorded. An additional inspection and corrective action should take as soon as possible. If corrective action via pruning or plant health care will not adequately eliminate the defect, tree removal may likely be the safest and most cost-effective management.

ROUTINE INSPECTIONS

Inspections are essential to uncovering potential problems with trees. They should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees. Arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care. Ideally, inspections would be conducted by an ISA Certified Arborist who may also have the ISA Tree Risk Assessment Qualification (TRAQ) credential.

Routine Inspection Recommendations

All trees along the greenways and within parks should be regularly inspected and attended to as needed. When trees require additional or new work, they should be added to the maintenance schedule. The budget should also be updated to reflect the additional work. Utilize computer management software such as TreeKeeper® to make updates, edits, and keep a log of work records. Routine inspections present an opportunity to look for unidentified defects, dead or poor condition trees, and signs and symptoms of pests and diseases.

DRG recommends that Monroe County continue to build on this initial inventory of significant trees by performing Level 2 basic inspections of park trees within the manicured areas. DRG conducted a Level 1 classified inventory of trees along greenways, trails, and near some other park structures. Having a complete inventory will provide Monroe County a better understanding of the public parks tree resource composition, functional benefit provided to the community, and maintenance needed. Longer-term goals for a sustainable urban forest resource can be set and educated actions can be planned and budgeted.

After a completing an inventory of all manicured landscapes, DRG recommends the following routine inspections:

- Walk-by assessment of four-fifths (approximately 80%) of all trees or county-managed area in line with *ANSI A300* (Part 9) annually.
- Walk-by assessment in line with *ANSI A300* (Part 9) after all severe weather events.
- Walk-around assessment of one-fifth (approximately 20%) of all trees or county-managed area in line with *ANSI A300* (Part 9) annually.

When trees need maintenance, they should be added to the work schedule and budgeted for immediately. Establishing a routine inspection protocol will keep the inventory and information gained most accurate.

TREE PLANTING AND STUMP REMOVAL

Planting new trees in areas where trees were previously is important. It is also important to plant trees in areas with poor canopy continuity or gaps in existing canopy. Stump removals should be performed either when a tree is removed or before a planting season begins, so planting sites become vacant for replacement trees.

Tree Planting and Stump Removal Recommendations

Most inventoried trees were found in natural areas where stump removal is not necessary. DRG figures there are about 27 trees that when removed the stump will also need removed. It is these trees DRG recommends replacing.

The focus of new plantings may occur in manicured landscapes where grass is mowed. DRG recommends Monroe County figure an achievable annual planting rate and budget for that annually. With the information about Monroe County's current forestry program DRG suggests that may be 25 trees annually.

The Right Tree in the Right Place is a mantra for tree planting used by the Arbor Day Foundation and many utility companies nationwide. Trees come in many different shapes and sizes, and often change dramatically over their lifetimes. Before selecting a tree for planting, make sure it is the right tree—know how tall, wide, and deep it will be at maturity.

Equally important to selecting the right tree is choosing the right spot for a reason to plant it. Examples of plantings types that would benefit the community are windbreaks, shading, water management, soil erosion, beauty, interest, air quality. Designing and correctly placing this would

provide numerous benefits such as reducing heat on people and trails, reducing water runoff, reduction of erosion that can damage trails, and removing of harmful air particles. Selective beauty and interest plantings can be used to educate the public about native trees and rare species.

A list of suggested tree species is provided in Appendix C. These tree species are specifically selected for the climate of Monroe County. This list is not exhaustive but can be used as a guideline for species that meet park objectives and enhance the existing species diversity and distribution.

YOUNG TREE TRAINING CYCLE

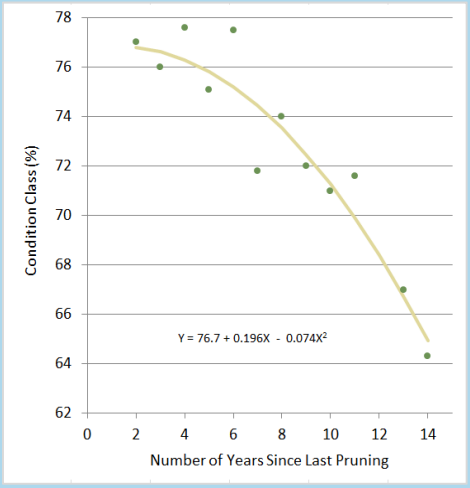
Trees included in the Young Tree Training Cycle are generally less than 8 inches DBH. These younger trees sometimes have branch structures that can lead to potential problems as the tree ages. Potential structural problems include codominant leaders, multiple limbs attaching at the same point, or crossing/interfering limbs. If these problems are not corrected, they may worsen as the tree grows, increasing its risk rating and creating potential liability.

The recommended length of a Young Tree Training cycle is three years because young trees tend to grow at faster rates than mature trees. The Young Tree Training Cycle only includes trees that can be pruned from the ground with a pole pruner or pruning shear.

Young Tree Training Cycle Recommendations

Monroe County should complete the inventory to include manicured landscaped areas and strive to training prune approximately one-third of its young trees each year. However, in this *Parks Tree Resource Management Plan* five-year management program DRG recommends that Monroe County implement a three-year Young Tree Training Cycle after the county begins planting trees.

PROACTIVE PRUNING



Relationship between tree condition and years since previous pruning.

(adapted from Miller and Sylvester 1981).

Miller and Sylvester studied the pruning frequency of 40,000 street trees in Milwaukee, Wisconsin. Trees that had not been pruned for more than 10 years had an average condition rating 10% lower than trees that had been pruned in the previous several years. Their research suggests that a five-year pruning cycle is optimal for urban trees.

Routine pruning cycles help detect and correct most defects before they reach higher risk levels. Davey Resource Group recommends that pruning cycles begin after all Extreme and High Risk tree maintenance has been completed.

Davey Resource Group recommends two pruning cycles: a Young Tree Training cycle and a Routine Pruning cycle. Newly planted trees will enter the Young Tree Training cycle once they become established and will move into the Routine Pruning cycle when they reach maturity. A tree should be removed and eliminated from the Routine Pruning cycle when it outlives its usefulness.

When new trees are planted, they should enter the Young Tree Training Cycle after establishment, typically within 2–3 years after planting. The Young Tree Training Cycle will be based on tree planting efforts and growth rates of young trees.

NATURAL AREA MANAGEMENT CONSIDERATIONS

DRG observed Monroe County has small sections of contiguous forest with interwoven trails and several invasive understory species such has honeysuckle and multiflora rose. DRG recommends Monroe County develop a forest area (natural area) management plan. Just like this risk-based management plan if there is not a plan in place, the random results will not produce desirable outcomes. A natural area management plan will identify objectives for specific areas, capture the composition of the specific area, and provide the information needed to establish goals, set actions, and project budgets for specific areas. Ultimately, the plan will show a greater returned benefit on investment.

An easy, returned benefit example, not often used because of public opinion, is a funding or material source made with timber management objectives. The revenue generated from a harvest could be used for park projects. Also, some lumber could be reused on site for park projects. Harvests would involve selective removal of specimen trees or patches that mimic forest clearings created by natural disturbance, such as wind-throw. With careful public outreach and education, harvests provide funding and promote the health of forest canopy and wildlife.

The natural area management plan should, at a minimum, contain an invasive vegetation control plan to remove or reduce the amount of invasive vegetation. This is especially relevant when tree removals result in canopy openings that allow sunlight to reach the forest floor potentially stimulating the growth of invasive vegetation in the understory. The returned benefit would be the prevention of their spread and improvement of wildlife occurrences and trails, parks and neighboring property aesthetics.

MAINTENANCE SCHEDULE AND BUDGET

Utilizing 2020 Monroe County tree inventory data, an annual maintenance schedule was developed detailing the recommended tasks to complete each year. DRG made budget projections using industry knowledge and public bid tabulations. A complete table of estimated costs for Monroe County's five-year tree management program follows.

This schedule provides a framework for completing the recommended inventoried tree maintenance over the next five years. Following this schedule can shift tree maintenance activities from being reactive to a more proactive tree care program.

To implement the prioritized maintenance schedule, Monroe County's tree maintenance budget should be no less than $30,000 for these five years of implementation. Projections of a proactive program in years 6 and 7 (Figure 1) show budget estimates flatten to near $29,800. After the first 5 years routine inspections, new priority maintenance, tree planting, and follow up care are projected. These projections do not include maintenance of manicured landscaped area trees.

Annual budget funds are needed to ensure that high and moderate priority trees are expediently managed and that the Routine Inspections, Tree Planting, and Young Tree Training Cycle can begin as soon as possible. From year to year, if routing efficiencies and/or contract specifications allow more

tree work to be completed, or if this maintenance schedule requires adjustment to meet budgetary or other needs, then it should be modified accordingly. Unforeseen situations such as severe weather events may arise and change the maintenance needs of trees. If maintenance needs change, then budgets, staffing, and equipment should be adjusted to meet the new demand.

Table 5. Estimated budget for recommended five-year tree resource management program

Activity Cost			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	Count	Cost	Count	Cost	Count	Cost	Count	Cost	Count	Cost	
High Priority Removals	1-3"	$43	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$85	1	$85	0	$0	0	$0	0	$0	0	$0	$85
	7-12"	$128	5	$425	0	$0	0	$0	0	$0	0	$0	$425
	13-18"	$510	3	$255	0	$0	0	$0	0	$0	0	$0	$255
	19-24"	$765	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$1,275	1	$85	0	$0	0	$0	0	$0	0	$0	$85
	31-36"	$1,530	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$2,040	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	>43"	$2,550	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**10**	**$850**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$850**
Moderate Priority Removals	1-3"	$43	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$85	6	$768	6	$768	0	$0	0	$0	0	$0	$1,536
	7-12"	$128	25	$3,200	30	$3,840	80	$10,240	66	$8,448	0	$0	$25,728
	13-18"	$510	25	$3,200	30	$3,840	24	$3,072	22	$2,816	0	$0	$12,928
	19-24"	$765	13	$1,664	20	$2,560	0	$0	0	$0	0	$0	$4,224
	25-30"	$1,275	15	$1,920	3	$384	0	$0	0	$0	0	$0	$2,304
	31-36"	$1,530	8	$1,024	0	$0	0	$0	0	$0	0	$0	$1,024
	37-42"	$2,040	3	$384	0	$0	0	$0	0	$0	0	$0	$384
	>43"	$2,550	2	$256	0	$0	0	$0	0	$0	0	$0	$256
Activity Total(s)			**97**	**$12,416**	**89**	**$11,392**	**104**	**$13,312**	**88**	**$11,264**	**0**	**$0**	**$48,384**
Stump Removals	1-3"	$22	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$28	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$43	0	$0	0	$0	0	$0	11	$308	0	$0	$308
	13-18"	$85	0	$0	0	$0	0	$0	6	$168	0	$0	$168
	19-24"	$107	0	$0	0	$0	0	$0	2	$56	0	$0	$56
	25-30"	$128	0	$0	0	$0	0	$0	3	$84	0	$0	$84
	31-36"	$150	0	$0	0	$0	0	$0	2	$56	0	$0	$56
	37-42"	$170	0	$0	0	$0	0	$0	2	$56	0	$0	$56
	>43"	$210	0	$0	0	$0	0	$0	1	$28	0	$0	$28
Activity Total(s)			**0**	**$0**	**0**	**$0**	**0**	**$0**	**27**	**$756**	**0**	**$0**	**$756**
High Priority Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$120	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	19-24"	$170	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$225	1	$225	0	$0	0	$0	0	$0	0	$0	$225
	31-36"	$305	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	>43"	$590	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**1**	**$225**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$225**

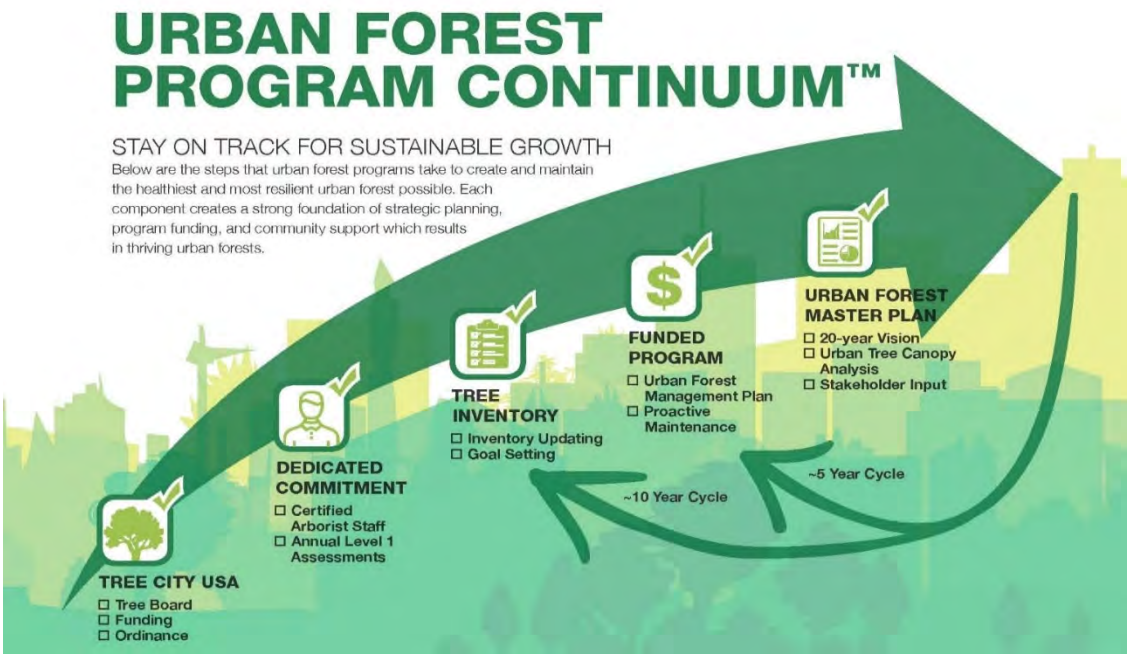
Activity Cost			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	Count	Cost	Count	Cost	Count	Cost	Count	Cost	Count	Cost	
Moderate Priority Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	0	$0	11	$2,475	11	$2,475	0	$0	0	$0	$4,950
	13-18"	$120	0	$0	12	$2,700	6	$1,350	0	$0	0	$0	$4,050
	19-24"	$170	8	$1,800	3	$675	0	$0	0	$0	0	$0	$2,475
	25-30"	$225	4	$900	0	$0	0	$0	0	$0	0	$0	$900
	31-36"	$305	2	$450	0	$0	0	$0	0	$0	0	$0	$450
	37-42"	$380	1	$225	0	$0	0	$0	0	$0	0	$0	$225
	>43"	$590	1	$225	0	$0	0	$0	0	$0	0	$0	$225
Activity Total(s)			**16**	**$3,600**	**26**	**$5,850**	**17**	**$3,825**	**0**	**$0**	**0**	**$0**	**$13,275**
Routine Inspection	Level 1 Assessment	$700/day	1	$700	1	$700	1	$700	1	$700	1	$700	$3,500
Activity Total(s)			**1**	**$700**	**1**	**$700**	**1**	**$700**	**1**	**$700**	**1**	**$700**	**$3,500**
Young Tree Training (3-Year Cycle)	1-3"	$20	0	$0	0	$0	0	$0	25	$4,250	25	$4,250	$8,500
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	6"<	$40	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**0**	**$0**	**0**	**$0**	**0**	**$0**	**25**	**$4,250**	**25**	**$4,250**	**$8,500**
Replacement Tree Planting and Maintenance	Purchasing	$170	0	$0	0	$0	0	$0	27	$4,590	0	$0	$4,590
	Planting	$110	0	$0	0	$0	0	$0	27	$2,970	0	$0	$2,970
	Watering	$100	0	$0	0	$0	0	$0	27	$2,700	0	$0	$2,700
	Mulching	$100	0	$0	0	$0	0	$0	27	$2,700	0	$0	$2,700
Activity Total(s)			**0**	**$0**	**0**	**$0**	**0**	**$0**	**108**	**$12,960**	**0**	**$0**	**$12,960**
New Tree Planting and Maintenance	Purchasing	$170	25	$4,250	25	$4,250	25	$4,250	0	$0	25	$4,250	$17,000
	Planting	$110	25	$2,750	25	$2,750	25	$2,750	0	$0	25	$2,750	$11,000
	Watering	$100	25	$2,500	25	$2,500	25	$2,500	0	$0	25	$2,500	$10,000
	Mulching	$100	25	$2,500	25	$2,500	25	$2,500	0	$0	25	$2,500	$10,000
Activity Total(s)			**100**	**$12,000**	**100**	**$12,000**	**100**	**$12,000**	**0**	**$0**	**75**	**$12,000**	**$48,000**
TBD Priority Maintenance	Any Size Classes	TBD	0	$0	0	$0	0	$0	0	$0	90	$12,547	$12,547
Activity Total(s)			**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**90**	**$12,547**	**$12,547**
Activity Grand Total			**225**		**216**		**222**		**141**		**191**		**995**
Cost Grand Total				**$29,791**		**$29,942**		**$29,837**		**$29,930**		**$29,497**	**$148,997**

CONCLUSION

When properly maintained, the valuable benefits trees provide over their lifetime far exceed the time and money invested in planting, pruning, and inevitably removing them. Successfully implementing the five-year program and completing the tree inventory in manicured landscape areas will increase Monroe County's return of investment over time.

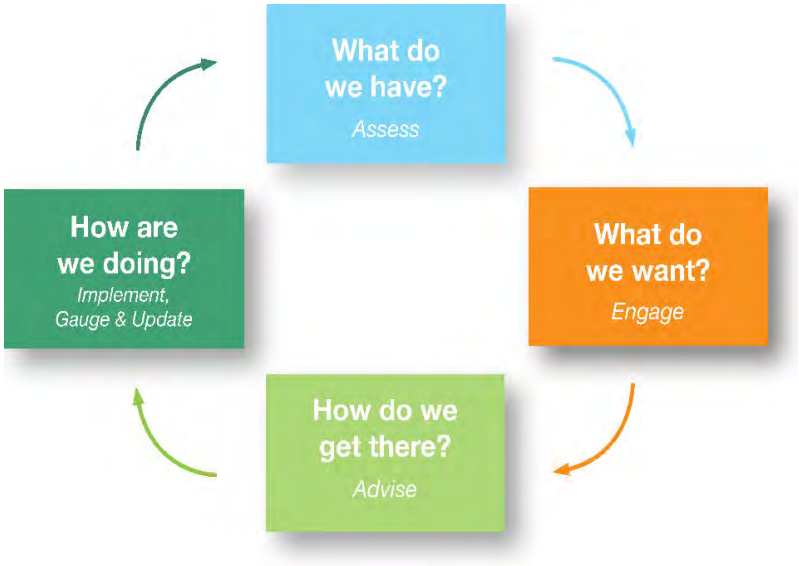
The program is ambitious and is a challenge to complete in five years but becomes easier after initial identified high and moderate priority tree maintenance is completed. This *Parks Tree Resource Management Plan* could help the county advocate for an increased urban forestry budget to fund the recommended maintenance activities and complete the inventory. Getting started is the most difficult part which Monroe County has done with this initial inventory and plan. With the implementation of this plan, Monroe County will actively transition from a reactive maintenance program to proactive maintenance program. Significant risk-based investments early on can reduce tree maintenance costs over time and provides the greatest benefit to the community.

Managing trees is often complicated, particularly when dealing with limited budgets and resources. Navigating the recommendations of experts, the needs of county residents, the pressures of local economics and politics, concerns for public safety and liability, physical components of trees, forces of nature and severe weather events, and the expectation that these issues are resolved all at once is a considerable challenge. The county must carefully consider these challenges to fully understand the needs of maintaining an urban forest. With the knowledge and wherewithal to address the needs of its trees, Monroe County is well positioned to thrive. If the management program is successfully implemented, the health and safety of county parks trees and park and recreation users will be maintained for years to come.



EVALUATING AND UPDATING THIS PLAN

This *Parks Tree Resource Management Plan* provides management priorities for the next five years, and it is important to update the tree inventory using TreeKeeper® as work is completed, so the software can provide update to date information. This empowers Monroe County to self-assess the county's progress over time and set goals to strive toward by following the adaptive management cycle. Below are some ways of implementing the steps of this cycle:



- Complete the inventory of manicured landscaped areas.
- Establish a routine inspection cycle to prescribed routine maintenance cycles which includes data collection such as measuring DBH, assessing condition, assessing risk, and recommending maintenance into standard procedure.
- Schedule and assign high and moderate priority tree work so it can be completed as soon as possible instead of reactively addressing new lower priority work requests as they are received.
- Prepare planting plans well enough in advance to schedule and complete stump removal in the designated area, and to select species best suited to the available sites.
- Annually compare the number of trees planted to the number of trees removed, then adjusting future planting plans accordingly.
- Annually compare the species distribution of the inventoried tree resource with the previous year after completing planting plans to monitor recommended changes in abundance.
- Have inventoried or re-inventoried all trees in 5 years and reproduce this plan with new information in comparison to historical analysis captured here in this *Parks Tree Resource Management Plan*.

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APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

DATA COLLECTION METHODS

DRG collects tree inventory data using their proprietary GIS software, called Rover, loaded onto pen-based field computers. At each site, the following data fields were collected and uploaded into DRG's proprietary inventory management software, called TreeKeeper®:

- Condition
- Date of Inventory
- Defect
- Diameter (DBH)*
- Further Inspection
- Grow Space
- Hardscape Damage
- Land Use
- Multi Stem
- Notes
- Overhead Utilities
- Park Name
- Primary Maintenance
- Risk Assessment and Rating
- Species Identification
- Tag Number
- X and Y Coordinates

* measured in inches in diameter at 4.5 feet above ground or diameter at breast height (DBH]).

The knowledge, experience, and professional judgment of DRG's arborists ensure the high quality of inventory data.

SITE LOCATION METHODS

Equipment and Base Maps

Inventory arborists use FZ-G1 Panasonic Toughpad® units with internal/external GPS receivers. Geographic information system (GIS) map layers are loaded onto these units to help locate sites during the inventory. This table lists these base map layers, along with each layer's source and format information.

Imagery/Data Source	Data Year	Projection
Monroe County, IN Parks and Recreation Department John Robertson	2018-2020	NAD 1983 StatePlane Indiana West; Feet

Greenway and Park Site Location

Location information was based on provided GIS data that identified the boundaries of the study areas. Sites were placed within or along these boundaries based on GPS and aerial imagery references.

APPENDIX B
i-TREE ECO METHODOLOGY

Understanding the values that the urban forest brings to a community is an important step in developing an urban forest management plan. DRG uses i-Tree software to develop a comprehensive analysis of the composition and benefits provided by an urban forest. i-Tree is a software program that was developed by the United States Forest Service with the support of the International Society of Arboriculture, Society of Municipal Arborists, Arbor Day Foundation, Casey Tree and The Davey Tree Expert Company. Utilized worldwide, i-Tree has provided a more scientific basis for managing trees within the urban forest for countless communities. i-Tree allows communities to understand the benefits that trees provide in simple, easy to understand ways. For this project, we propose the use of i-Tree Eco. i-Tree Eco will provide information about the public tree inventory as a component of the overall urban forest.

DRG will use i-Tree Eco to create an expansive snapshot of the public tree inventory. It informs the condition of the urban forest allowing tree managers to develop a focus on the structure, function, and value of the trees in the community. That focus will be specifically on species composition and diversity, current condition, risk potential for invasive pests, primary environmental benefits, and management needs. i-Tree Eco will apply local hourly air pollution and meteorological data to improve the estimation of environmental benefits.

The i-Tree Eco analysis will provide the following information:

- Urban forest composition, including species composition and diversity, condition, and age distribution;
- Hourly amount of pollution removed by the urban and community forest and associated percent air quality improvement throughout a single year. Pollution removal is calculated for ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter <10 microns (PM_{10}).
- Hourly urban and community forest volatile organic compound emissions and the relative impact of tree species on net ozone and carbon monoxide formation throughout the year.
- Total carbon stored and net carbon annually sequestered by the urban and community forest(s).
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power plants.
- Compensatory value of the forest, as well as the value of air pollution removal and carbon storage and sequestration.
- Tree pollen allergen city index.
- Potential impact of pests and diseases such as emerald ash borer and oak wilt.

The Monroe County i-Tree Eco analysis report and project file can be found on the USB drive.

Benefit Prices Used by i-Tree Eco in the Analysis of Monroe County's Tree Inventory

Benefits	Price	Unit	Source
Electricity	$0.12	$/kWh	iTree Eco 2018
Natural Gas	$0.93	$/Therm	iTree Eco 2018
CO_2	$0.66	$/lb	iTree Eco 2018
PM10	$27.62	$/lb	iTree Eco 2018
NO2	$0.20	$/lb	iTree Eco 2018
O3	$1.43	$/lb	iTree Eco 2018
SO2	$0.10	$/lb	iTree Eco 2018
Stormwater Interception	$0.50	$/gal	iTree Eco 2018

Using these prices, the magnitude of the benefits provided by the public tree resource was calculated based on the science of i-Tree Streets using DRG's TreeKeeper® inventory management software. For a detailed description of how the magnitudes of benefit prices are calculated, refer to the *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planning* (McPherson et al. 2009).

APPENDIX C
SUGGESTED TREE SPECIES FOR USDA HARDINESS ZONE 6

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout Zone 6 on the USDA Plant Hardiness Zone Map.

DECIDUOUS TREES

Large Trees (greater than 45 feet in height when mature)

Scientific Name	Common Name	Cultivar
Acer rubrum	red maple	Red Sunset®
Acer nigrum	black maple	
Acer saccharum	sugar maple	'Legacy'
*Acer saccharinum**	silver maple	
*Aesculus glabra**	Ohio buckeye	
*Aesculus flava**	yellow buckeye	
Betula nigra	river birch	Heritage®
*Carya illinoensis**	pecan	
*Carya laciniosa**	shellbark hickory	
*Carya ovata**	shagbark hickory	
*Castanea mollissima**	Chinese chestnut	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(numerous exist)
Ginkgo biloba	ginkgo	(male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Juglans regia**	English walnut	'Hansen'
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	Cherokee™
Liriodendron tulipifera	tuliptree	'Fastigiatum'
Maclura pomifera	osage-orange	'White Shield','Witchita'
*Magnolia acuminata**	cucumbertree magnolia	(numerous exist)
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'

Large Trees (greater than 45 feet in height when mature) (Continued)

Scientific Name	Common Name	Cultivar
Nyssa sylvatica	black tupelo	
Platanus × *acerifolia*	London planetree	'Yarwood'
*Platanus occidentalis**	American sycamore	
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus ellipsoidalis	northern pin oak	
Quercus frainetto	Hungarian oak	
Quercus imbricaria	shingle oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus phellos	willow oak	
Quercus robur	English oak	Heritage®
Quercus rubra	northern red oak	'Splendens'
Quercus shumardii	Shumard oak	
Quercus texana	Texas oak	
*Sassafras albidum**	Sassafras	
Styphnolobium japonicum	Japanese pagodatree	'Regent'
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Greenspire'
Tilia tomentosa	silver linden	'Sterling'
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	'Green Vase'

Medium Trees (31 to 45 feet in height when mature)

Scientific Name	Common Name	Cultivar
Aesculus × *carnea*	red horsechestnut	
*Asimina triloba**	pawpaw	
Carpinus betulus	European hornbeam	'Franz Fontaine'
Cladrastis kentukea	American yellowwood	'Rosea'
Eucommia ulmoides	hardy rubbertree	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	eastern hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense	amur corktree	'Macho'
Prunus maackii	amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
Sorbus alnifolia	Korean mountainash	'Redbird'

Small Trees (15 to 30 feet in height when mature)

Scientific Name	Common Name	Cultivar
Acer buergerianum	trident maple	Streetwise®
Acer campestre	hedge maple	Queen Elizabeth™
Acer cappadocicum	coliseum maple	'Aureum'
Acer ginnala	amur maple	Red Rhapsody™
Acer griseum	paperbark maple	
*Acer pensylvanicum**	striped maple	
Acer truncatum	Shantung maple	
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	
Amelanchier canadensis	shadblow serviceberry	(numerous exist)
Amelanchier laevis	Allegheny serviceberry	
Carpinus caroliniana	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
Chionanthus virginicus	white fringetree	
Cornus alternifolia	pagoda dogwood	
Cornus kousa	Kousa dogwood	(numerous exist)
*Cornus mas**	corneliancherry dogwood	'Spring Sun'
Corylus avellana	European filbert	'Contorta'
*Cotinus coggygria**	common smoketree	'Flame'
*Cotinus obovata**	American smoketree	
Crataegus phaenopyrum	Washington hawthorn	Princeton Sentry™
Crataegus viridis	green hawthorn	'Winter King'
Euonymus atropurpureus	eastern wahoo	
*Franklinia alatamaha**	Franklinia	
Halesia tetraptera	Carolina silverbell	'Arnold Pink'
*Magnolia × soulangiana**	saucer magnolia	'Alexandrina'
*Magnolia stellata**	star magnolia	'Centennial'
*Magnolia tripetala**	umbrella magnolia	
*Magnolia virginiana**	sweetbay magnolia	Moonglow®
Malus spp.	flowering crabapple	(disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
Prunus americana	American plum	
Prunus subhirtella	Higan cherry	pendula
Prunus virginiana	common chokecherry	'Schubert'
*Rhus aromatic**	fragrant sumac	
*Rhus glabra**	smooth sumac	
*Rhus typhina**	staghorn sumac	
*Staphylea trifolia**	American bladdernut	
Styrax japonicus	Japanese snowbell	'Emerald Pagoda'
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

CONIFEROUS AND EVERGREEN TREES

Large Trees (greater than 45 feet in height when mature)

Scientific Name	Common Name	Cultivar
Abies balsamea	balsam fir	
Abies concolor	white fir	'Violacea'
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
Ilex opaca	American holly	
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Pinus densiflora	Japanese red pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Psedotsuga menziesii	Douglasfir	
Thuja plicata	western arborvitae	(numerous exist)
Tsuga canadensis	eastern hemlock	

Medium Trees (31 to 45 feet in height when mature)

Scientific Name	Common Name	Cultivar
Chamaecyparis thyoides	Atlantic whitecedar	(numerous exist)
Juniperus virginiana	eastern redcedar	
Pinus bungeana	lacebark pine	
Pinus flexilis	limber pine	
Thuja occidentalis	eastern arborvitae	(numerous exist)

Small Trees (15 to 30 feet in height when mature)

Scientific Name	Common Name	Cultivar
Ilex × attenuata	Foster's holly	
Pinus aristata	bristlecone pine	
Pinus mugo	mugo pine	

Dirr's Hardy Trees and Shrubs (Dirr 2013) and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1988) were consulted to compile this suggested species list. Cultivar selections are recommendations only and are based on DRG's experience. Tree availability will vary based on availability in the nursery trade.