

*Boone County Forest
Canopy Cover:
Public Health and Safety
Function Analysis
And Development of Guidelines
for Environmental Protection*



**Northern Kentucky
Urban and
Community
Forestry Council**

February, 2004

DAVEY 
RESOURCE GROUP
A Division of The Davey Tree Expert Company

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Introduction

Boone County is a rapidly growing area in Northern Kentucky and is one of the fastest-developing areas in the state. People and businesses are attracted to Boone County for many reasons, including its economic development policies, access to major interstates and the regional airport, the availability of employment, and its cultural and historic attractions.

Another major reason for Boone County's popularity, especially among homeowners, is the ability to live in a rural or suburban setting and to enjoy the benefits of the many natural resources and forest cover found in the county. The forests provide many aesthetic, economic, and environmental benefits to the residents, businesses, workers, and visitors of Boone County, and even to the tri-state region as a whole.

Sometimes the success of a place, however, can threaten the very reasons and resources that made it so attractive in the first place. Rapid development can lead to staggering losses of greenspace and urban and rural forest resources. Clear-cutting building sites for construction, accidental damage, utility excavation, road construction, land grade changes, and pollution from developing areas destroys millions of trees each year.

Boone County's urban and community forest resources have a great deal of financial value, from increased property values to various environmental benefits. Trees stabilize the soil and control water pollution, yield advantageous microclimatic effects that conserve energy, preserve and foster air quality by removing carbon dioxide and airborne pollutants, abate visual and noise pollution, provide effective stormwater control, and provide a natural habitat for wildlife. In addition to environmental benefits, trees also provide welcome shade to people and add color and interest to the landscape. Studies have shown that people are generally more satisfied with their neighborhoods, workers are more productive, and hospital patients recover faster if they can see trees outside their windows.

Information on the location, quantity, quality, and the benefits of forests is essential for professional community forest management. With this information, the County and its citizens will have detailed information about their forests and open spaces throughout Boone County. These data can be used as the starting point for educating citizens and decision-makers about the importance of making future urban forestry management and development decisions.

Goals and Purpose

In January 2002, the Northern Kentucky Urban and Community Forestry Council initiated a study of the tree canopy cover on both private and public property in Boone County and ordered the subsequent mapping of this natural resource. The project was completed in October 2002, and the Council obtained information that documented the size, location, and relative quality of forest canopy cover in Boone County.

The data collected and presented to the Council included the location, size, and ecological characteristics of forest tracts over ten acres in size in rural areas and five acres in size in the incorporated areas within Boone County. The Council believes this basic information, and subsequent analysis of it in terms of the many different and tangible benefits derived from forests, will help develop an understanding of community forest's ecological services and community benefits. With this understanding, urban and community forests can be integrated into decisions on growth, development, and community planning.

Forests provide many tangible and intangible benefits to the citizens of Boone County.

- *Economic:* Jobs, revenue, and taxes from timber harvesting and tree care activities; increased property values; attracting and retaining businesses and employees; providing recreational job and business opportunities; providing materials and resources for building and commerce; decreasing expenditures for mitigating stormwater and pollution problems; and conserving heating and cooling expenses.
- *Environmental:* Moderating climates; filtering air, soil, and water pollution; and providing oxygen.
- *Ecological:* Providing wildlife habitat; stabilizing soils; promoting biodiversity; and protecting and enhancing streams and rivers.
- *Psychological:* Providing beauty; calming emotions; quieting streets and neighborhoods; and providing places for relaxation and education.

There are many benefits of forests, and each benefit deserves detailed study and documentation. However, a primary goal of the Council is to document the specific benefits and provide useful information on the forests in Boone County regarding the values and benefits of the existing forest canopy cover in relation to public health and safety issues.

The goal of this study was to analyze known natural and man-made conditions in Boone County in relation to the remaining forest canopy cover. The analysis identified high-priority issues and areas of concern and quantified the public health and safety benefits of forests within the County. In addition, it provided a rationale for protecting environmentally sensitive forests via public education, legislation, and a variety of land use controls based on public health and safety functions.

This study can serve as means for the Council to educate decision-makers and citizens, encourage new land development policies, and potentially revise current zoning based on public health and safety functions performed by rural and urban forests.

Methodology

Davey analyzed current Geographic Information Systems (GIS) information of Boone County and information from other sources to provide measurements of the general public health and safety benefits of woodland resources such as:

- Stabilizing soils;
- Cleansing pollutants;
- Improving air quality; and
- Improving water quality.

Davey assigned public health and safety values to the forest canopy cover and other factors that directly and indirectly affect public health and safety, such as flooding, erosion, water quality, groundwater recharge, and watershed protection in the County. Please refer to the *Critical Areas Assessment* section for a detailed explanation of the methods used to assign these values and identify the critical areas of Boone County forest canopy cover.

Overview

Boone County, located in northern Kentucky, supports approximately 59,396 acres of forest canopy cover, which is 36 percent of the land cover in the County. Boone County is nearly two-thirds developed or in other non-forested land uses. The forest canopy cover mapped in Boone County is shown on Map 1. Map 2 shows black and white aerial photographs of Boone County that identifies the general development patterns of the County. Map 3 shows the general topographic features of Boone County.

In a previous study, the *Boone County Forest Quality Assessment* commissioned by the Council, general data were developed about the location and crown size of forest canopy cover in Boone County (NKU ERMC, 2002). Forest canopy cover identified in Boone County included areas with consistent cover ten acres in size and larger in unincorporated areas and five acres in size and larger in incorporated areas of the County. The study did not include street trees or landscape trees

Forest canopy cover identified throughout the County was classified into three crown size classifications:

1. Large crowns include trees with a diameter greater than 18 inches;
2. Medium crowns include trees with a diameter between 12 and 18 inches; and
3. Small crowns include seedlings, saplings, and successional trees 2 to 12 inches in diameter.

The countywide forest quality assessment results are summarized in Tables 1, 2, and 3, which show statistics for the County and incorporated areas.

Table 1. Boone County Forest Canopy Cover

	Area (acres)	Percent of County
Boone County	164,469	
Forest Canopy Cover Crown Size		
Large	2,865	2%
Medium	17,398	11%
Small	39,132	24%
Total Canopy Cover	59,396	36%

Table 2. Boone County Forest Canopy Cover Crown Size

Crown Size	Area (acres)	Percent
Large	2,865	5%
Medium	17,398	29%
Small	39,132	66%
Total Canopy Cover	59,396	

Table 3. Forest Canopy Cover in Walton, Union, and Florence

Crown Size	Area (acres)	Percent of Total Canopy Cover
Forest Canopy Cover in Walton		
Large	0	0.00%
Medium	29	0.05%
Small	201	0.34%
Total	230	0.39%
Forest Canopy Cover in Union		
Large	40	0.07%
Medium	16	0.03%
Small	85	0.14%
Total	142	0.24%
Forest Canopy Cover in Florence		
Large	18	0.03%
Medium	63	0.11%
Small	313	0.53%
Total	394	0.66%
All Municipalities		
Large	59	0.10%
Medium	108	0.18%
Small	599	1.01%
Total	766	1.29%

Source: NKU ERM, 2002

Forests make up 36 percent of the land cover in Boone County; nearly two-thirds (64 percent) of the land cover is developed or in other non-forested land uses. The vast majority of the forest cover is located in the western portion of the county where there is the least urban development. Of the county's forest resources, only one percent was found within municipal and incorporated boundaries.

Of the forest cover within the county, 66 percent has been classified as small. Small diameter and small crown size means the forest cover is in the primary and secondary stages of succession. This condition is likely due to agricultural field areas being left fallow for twenty or more years and/or routine timber harvesting occurring on the sites. The medium-sized trees account for 29 percent of the forest cover.

The larger diameter and crown size trees make up only 5 percent of the total forest and only 1.7 percent of Boone County's land cover. These areas of mature trees are located primarily on steep slopes or near stream corridors where land clearing for agriculture or timber harvesting was not practical.

The American Forestry Association, through research and numerous studies, has determined that the following forest canopy cover rates are desirable to obtain the benefits of urban and suburban forests:

- 60 percent canopy cover in low-density residential areas;
- 40 percent canopy cover in high-density residential areas;
- 25 percent canopy cover in mixed commercial use areas; and
- 10 percent in highly urbanized, downtown areas (American Forests, 1999).

The incorporated and highly developed areas of the county are lacking in sufficient forest cover to receive the many benefits of trees. Where there is currently sufficient forest cover, these areas should be protected or developed in such a way as to retain the greatest amount of forest cover and promote reforestation.

MAP 1: Overview

MAP 2: Aerial Photography

MAP 3: Elevation

Trees in Sensitive Areas of Boone County

In following sections of this report, the benefits of trees as they relate to direct public health and safety benefits will be fully discussed. The benefits analyzed in detail in this study include floodwater abatement, water quality improvement, and soil stabilization. In addition to these benefits, the forests in Boone County also function to provide other services, such as improving air quality and controlling stormwater, which are also linked to many public health issues. These functions were not specifically studied in this project, but are important to understanding the breadth and value of forest canopy cover in the county.

Air Quality Benefits of Trees

Air pollution is not only a major human health risk, but also reduces visibility and damages vegetation and man-made materials. Trees and vegetation improve air quality.

Solid matter, such as dust and dirt, and chemical particles, such as nitrogen oxide, sulfur dioxide, carbon monoxide, carbon dioxide, and ozone in the air is absorbed by trees through their leaves. This process filters solid and chemical pollutants from the air before they reach street level. There is up to a 60 percent reduction in street level particulates with trees. One sugar maple, 12 inches at diameter breast height, along a roadway removes from the environment in one growing season: 60 milligrams (mg) cadmium; 140 mg chromium; 820 mg nickel; and 5,200 mg lead (Davey, 1993).

In addition, urban forests in the United States absorb and store millions of tons of carbon annually, reducing the level of carbon dioxide in the atmosphere (McPhearson, et. al., 1999). Carbon dioxide, a by-product of burning fossil fuels, is one of the primary compounds influencing global warming.

Not only do trees absorb carbon dioxide, but the shade and evaporative cooling benefits they provide aid in the reduction of carbon emissions from power generating plants as shown in Figure 1. By decreasing the ambient air temperature, the demand for electricity decreases, therefore reducing carbon emissions from power plants supplying the energy to cool buildings (USDAFS, 2003).

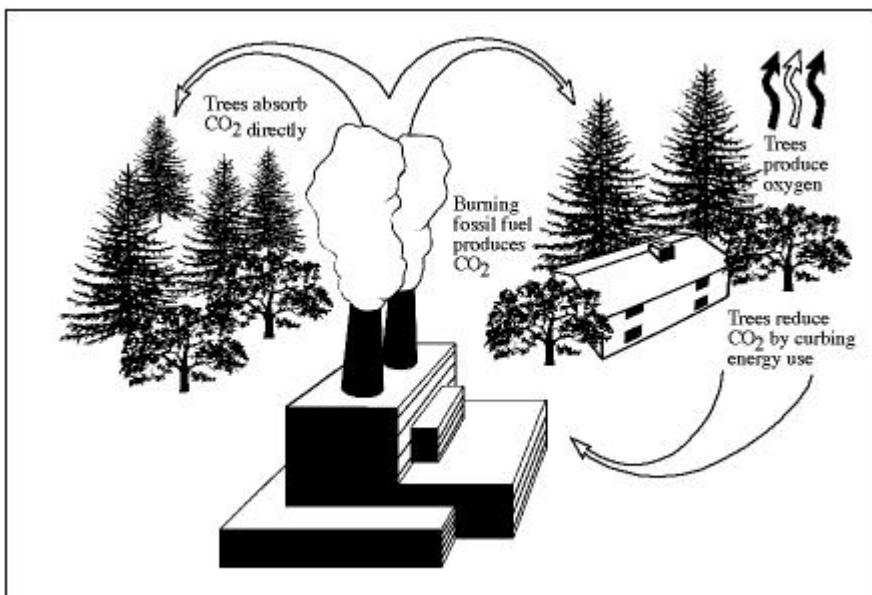


Figure 1. Trees can help improve air quality by absorbing carbon dioxide, which is produced during the photosynthesis process, and by shading buildings. That results in reduced amounts of carbon dioxide from the production of energy (USDAFS, 2003).

A community benefits not only from cleaner air, but also from the reduced cost of implementing air pollution controls. In one study of a 525-acre urban park, tree cover daily removed: 48 pounds of particulates; 9 pounds of nitrogen dioxide; 6 pounds of sulfur dioxide; 2 pounds of carbon monoxide; and 100 pounds of carbon. Based on pollution control technology, the carbon monoxide removal alone is valued at \$136 per day (Davey, 1993). Using these and the statistics from the Boone County forest canopy cover study, the 59,396 acres of forest cover countywide could remove 60,225 pounds of pollutants annually.

Stormwater Management Benefits of Trees

Trees and other vegetation in the landscape are a community's green infrastructure and affect both the quantity and quality of stormwater runoff. When land is left in a natural state, forests and other ecological components of the landscape decrease the quantity of stormwater runoff by allowing water to be absorbed into the soil and retained in wetlands and other areas. Forests decrease the pollutants often found in stormwater runoff, by filtering the contaminants through the soil and through root system uptake; however, poorly planned urban development destroys many of the natural resources that are important in maintaining high water quality and reducing the incidence and severity of flooding.

As urban areas expand, the need for stormwater management services escalates, while trees and greenspaces are lost to development. Protecting forests, greenspaces, and waterways is critical to long-term economic growth and public safety. The historic response of agencies charged with stormwater management has been to engineer structural solutions to control stormwater. While this approach is necessary as urbanization occurs, there are other supplemental best management practices and proactive planning approaches involving urban and community forestry that may reduce the needs for extensive and expensive hardscape solutions.

Trees naturally help manage stormwater quantity and quality in many ways. One way is through interception of rainfall. Tree canopies capture and store rainfall on its leaf and woody surfaces. The amount of water that reaches the ground is then absorbed into the soil. The trees of the forest then either directly absorb the water through their extensive root systems for their own needs or the water is absorbed into the forest soil and slowly released underground to streams. The filtering of rainwater and surface runoff through a forest and the forest soils also traps pollutants before they reach surface waters and underground aquifers.

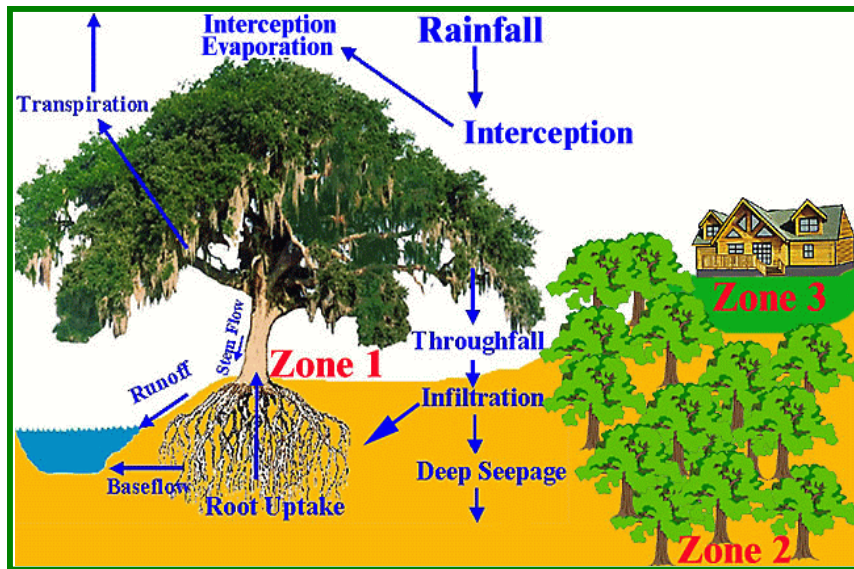


Figure 2. Forests play a critical role in naturally reducing stormwater runoff and improving runoff water quality through a complex and dynamic system involving all parts of the tree and the soil's characteristics (Passmore, 2004).

One of the greatest benefits forests provide stormwater managers and communities, is their ability to store and slowly release excess water. A primary concern during a storm event in a developed area is the amount of stormwater runoff occurring over a short period due to the creation of impervious surfaces. When stormwater runoff quantities peak rapidly and early during storms, often the designed, structural stormwater management devices fail and severe damage is caused by widespread flooding and quickly moving waters.

By combining the use of structural, manufactured devices with the retention of continuous forest areas in developed areas, communities can realize significant benefits in public health and safety and in infrastructure construction and maintenance costs.

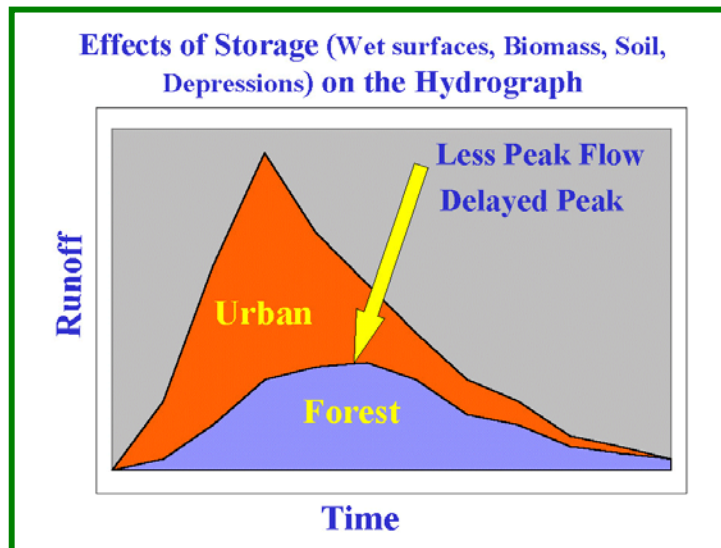


Figure 3. Forested areas retain and release water from storm events in lesser quantities and over longer periods (Passmore, 2004).

Floodplains

Boone County has a total of 5,024 acres of floodplain; of that, 1,323 acres (26 percent) are forested. Map 4 shows the location of the floodplains in Boone County. Floodplains identified are the 100-year flood areas that were mapped by the Boone County GIS Services Division. The majority of the floodplains in the County are associated with the Ohio River floodplain. Table 4 shows the distribution of the crown size classifications on the forested floodplain areas. The majority (67 percent) of the forest cover on floodplains is classified as small crown trees.

Table 4. Floodplains in Boone County Forest Canopy Cover

Crown Size	Area in Floodplain (acres)	Percent of Total Floodplain
Large	12	0.2%
Medium	419	8.3%
Small	892	17.8%
Total	1,323	26.3%

Benefits of Trees in Floodplains

Floodplains temporarily store floodwaters. Flooding is a natural and recurring event for a river or stream resulting from heavy or continuous rainfall that exceeds the absorptive capacity of soil and the flow capacity of rivers and streams. This causes a watercourse to overflow its banks onto adjacent lands. Floodplains are, in general, those lands most subject to recurring floods, situated adjacent to rivers and streams. The presence, size, and quality of forest cover in the floodplain have significant public health and safety implications as well as economic implications.

Forested floodplains reduce the severity of flooding by storing and slowly releasing floodwaters. By retaining floodwaters, these forested floodplains reduce the velocity and quantity of water released, reducing bank erosion in the associated river or stream. River and stream bank erosion potential is also decreased due to the presence of the root systems of these forested areas that stabilize and reinforce the top soil layers.

After the 1993 floods in Missouri, damage to cropland in and adjacent to floodplains of the Missouri and Mississippi Rivers could have been averted if there were more trees in the floodplain. The forested areas of the floodplains provided a mechanism to trap silt and sand particles and decrease the energy of floodwaters. Croplands adjacent to these forested areas experienced less erosion, sedimentation, and accumulation of debris; whereas, extensive damage was associated with areas not protected by forests (Hershey, 1994).

Trees and other floodplain vegetation help improve water quality by filtering water as it flows through the floodplain and into the associated river or stream. Trees absorb the energy from floodwaters and cause the deposition of suspended sediments. Attached to those sediments are often pollutants such as plant and animal wastes, nutrients, pesticides, petroleum products, metals, and other compounds that can compromise water quality and the health of both animals and humans. Once the contaminated sediments fall out, floodplain vegetation can assimilate these compounds, in a sense trapping them, and remove them from the water cycle.

Map 4: Floodplains

Riparian Zone

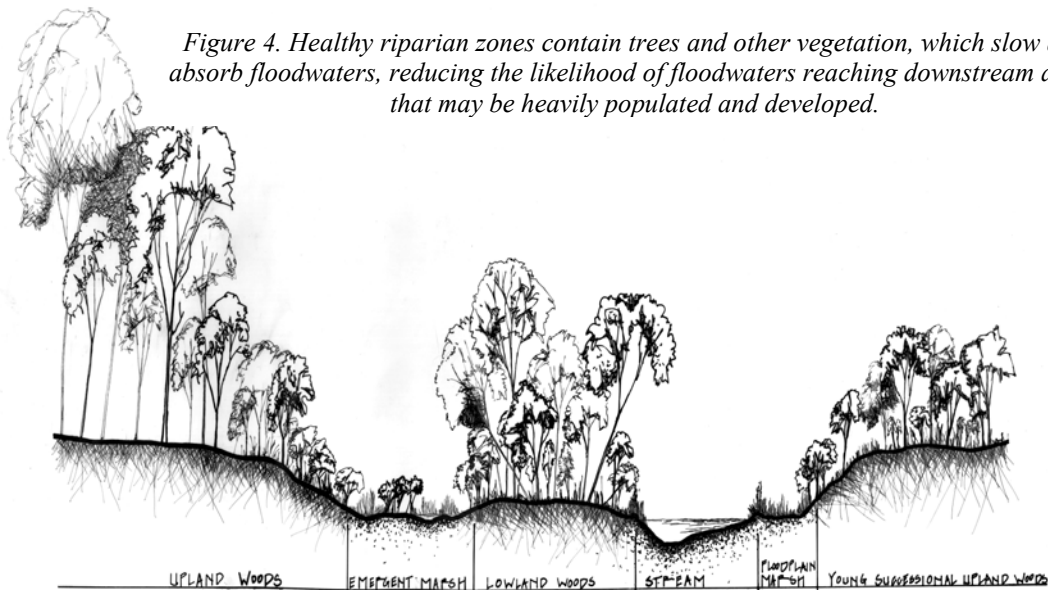
In Kentucky, current best management practices for forestry operations recommend limiting or prohibiting activity in riparian zones in areas ranging from 25 to 165 feet depending upon slope; however, riparian zones can vary in size depending upon the size of the watershed the streams are draining. Since this report is studying the public health and safety benefits of forests only, the riparian area or zone is defined as the area within 300 feet of a watercourse or the 100-year floodplain; whichever is greater. Therefore, the total riparian zone in Boone County is 56,387 acres. These riparian areas make up 34 percent of the County. Of the total riparian zone, only 41 percent is wooded. Map 5 identifies the riparian zones throughout Boone County. Table 5 shows the total forest canopy cover in the riparian zone based on the crown size.

Table 5. Riparian Zone in Boone County Forest Canopy Cover

Crown Size	Area within Riparian Zone (acres)	Percent of Total Riparian Area
Large	1,063	2%
Medium	7,324	13%
Small	14,419	26%
Total	22,806	41%

Benefits of Trees in the Riparian Zone

Riparian woodlands are important for public health and safety, as well as for recreation use and wildlife habitat. Riparian woodlands are the areas of woody and herbaceous vegetation along the sides of rivers and streams. When these zones are biologically healthy—comprised of trees, shrubs, and herbaceous plants—they perform functions that protect and sustain the nearby waterways including: absorption and removal of pollutants from runoff; flood abatement; groundwater recharge; reduction in water temperature extremes; and a source of organic matter to provide carbon nutrients (the most basic link in the food chain of a river ecosystem). An example of a healthy riparian zone is shown in Figure 4.



Forested riparian zones are especially effective in mitigating the economic and public health costs of soil and water pollution and erosion. Nitrates from agrochemicals or animal wastes can pollute surface or ground waters. Forested riparian zones have been shown to naturally cleanse nitrates from stormwater (Lowrance, 1992). In addition, forests along streams effectively remove organic contaminants such as aromatic hydrocarbons, herbicides, and solvents. Trees located in the riparian zone are highly effective in filtering runoff, settling sediments, and reducing the quantity of nutrients and pesticides before they enter a stream. Water infiltration rates in forested riparian zones are often 10 to 15 times greater than turf grass and 40 times greater than a plowed agricultural field (American Rivers, 2003).

In addition, riparian zones can afford opportunities for recreation. Riparian zones provide fish and wildlife the places they need to feed and reproduce. Nearly 70 percent of all vertebrate species rely upon the land along a river or stream's edge during their life cycle (American Rivers, 2003). Healthy, forested riparian zones create a vegetated transition zone between rivers or streams and upland habitats, providing shelter, food, and migration corridors for wildlife. Without forested streams, recreational activities, such as fishing, hunting, and bird watching, would be diminished, as would the economic benefits they bring to the communities.

Map 5: Riparian Zones

Groundwater Recharge and Sensitivity

Groundwater recharge rate and sensitivity is an often-overlooked area of concern for public health and safety. Groundwater recharge refers to the rate that underground water sources can replenish themselves in proportion to the rate at which they are being depleted for drinking, home, and agricultural use. Groundwater sensitivity relates to the susceptibility of the underground water source to be affected by pollutants and contaminants. Most governments want to insure that their citizens have access to plentiful and safe groundwater supplies as needed. In our interconnected world today, most governments do not want their land use activities to negatively affect others outside of their boundaries.

In Kentucky, there are five numerical classifications of groundwater sensitivity, with 1 representing the lowest sensitivity and 5 the highest sensitivity. In Boone County, only areas with ratings of 2 through 4 are found. Generally, the rocks of the Outer Bluegrass Region contain higher percentages of shale layers and do not develop extensive karst features, and therefore have areas of sensitivity ranging from 2 to 3. The geologic composition of the Ohio River Alluvium is primarily glacial outwash sediments; groundwater can migrate quickly through these coarser sediments and consequently is rated 4—highly sensitive (Ray, *et al.*, 1994).

Map 6 identifies the groundwater sensitivity ratings for Boone County. Only a small portion of the County (five percent) received a sensitivity rating of 4; these areas included mostly lands immediately adjacent to the Ohio River. The majority of the County is rated 3 (60 percent). The majority (63 percent) of forest canopy cover is located on areas with a sensitivity rating of 2. Table 6 shows the sensitivity ratings in relation to the three forest canopy size classes and the percentage of those areas with forest cover.

Table 6. Groundwater Recharge and Sensitivity and Forest Canopy Cover Crown Size

Sensitivity	Crown Size	Area (acres)	Total Forested Area (acres)	Total Area in County (acres)	Percent Forested
2	Small	23,930	35,211	56,321	63%
	Medium	9,821			
	Large	1,460			
3	Small	13,797	21,906	99,185	22%
	Medium	6,865			
	Large	1,244			
4	Small	1,195	1,844	8,963	21%
	Medium	497			
	Large	152			

Benefits Trees Provide to Sensitive Groundwater Recharge Areas

Groundwater is a vital, renewable natural resource. Groundwater resources and their characteristics are important to understand because of their potential to supply public drinking water and their hydrologic connection to surface waters. Wells and springs provide some of the domestic water supplies in Boone County. Surface streams and rivers, the major source of Boone County's water supply, are sustained during base flow by groundwater discharge from adjacent aquifers.

Groundwater flows through surface sediments and bedrock. Where the groundwater is near the surface, it often interacts with surface waters, flowing through streams, wetlands, and water bodies. The interaction between the groundwater and surface water bodies is cyclic. Groundwater often provides water to surface water resources and may be recharged by the same surface water sources.

This resource is susceptible to contamination from a variety of activities at the land surface. Groundwater contamination can be difficult or impossible to remediate. Since nearly one-third of Kentucky citizens get their water from wells and springs, the Kentucky Department for Environmental Protection has made the prevention of groundwater contamination a high priority.

When groundwater is contaminated, serious public health and safety consequences can result. Groundwater can be contaminated with disease-causing viruses and bacteria from human and animal waste. Excess nutrients from fertilizers and the chemical components of pesticides can be toxic to humans. Metals and organic chemicals from industry, agriculture, and residential land use and management can seriously degrade groundwater supplies.

Forests can protect groundwater from contamination in many ways. For instance, they can filter, reduce, and capture airborne and soilborne pollutants before they enter the groundwater regions. The existence of forest cover also precludes the use of the land for other highly damaging and contaminating land use activities such as mining, landfills, underground storage tanks, and creation of impervious surfaces. In addition to filtering out pollutants, floodplain trees and plants prevent erosion by anchoring riverbanks and streambanks, therefore playing an important role in recharging groundwater supplies.

Map 6: Groundwater Recharge

Highly Erodable Soils

Approximately 92 percent of the forest canopy cover contains highly erodable soils. The list of highly erodable soils was obtained from the Boone County Conservation District and is identified in Appendix B. Table 7 presents the cumulative calculations of all erodable soils located in the Boone County forest canopy cover based on crown size.

Table 7. Erodable Soils in Boone County Forest Canopy Cover

Crown Size	Total Canopy Cover (acres)	Canopy Cover on Highly Erodable Soils (acres)	Percent
Large	2,865	2,720	95%
Medium	17,398	16,417	94%
Small	39,132	35,232	90%
Total	59,396	54,369	92%

Since the majority of the forest canopy cover in Boone County is located on highly erodable soils, Map 7 only shows where highly erodable soils are located on slopes greater than 12 percent. This study uses a 12 percent threshold based on the standard practices of the Natural Resources Conservation Service (NRCS). Forest cover and best management practices positively impact erosion control on slopes greater than 12 percent, while geotechnical engineering solutions are required on slopes greater than 20 percent.

Benefits of Trees on Lands with Highly Erodable Soils

Soil erosion can be a serious problem in areas with steep slopes and small streams. Soil erosion and sedimentation into waterways poses several threats to public health and safety that are difficult and expensive to correct. Negative effects of erosion include:

- Altering and weakening soil texture, structure, and stability making it more susceptible to extreme conditions such as drought;
- Removing topsoil along with organic matter and nutrients;
- Contaminating and polluting downstream water sources and recreational areas with pesticides and fertilizers that are frequently transported in eroding soil; and
- Increasing sedimentation in streams, rivers, and reservoirs.

Boone County is particularly prone to soil erosion due to numerous steep slopes and increasing development pressure. Erosion is a problem wherever vegetation cover is removed and/or the soils are disturbed. Erosion can be especially severe in agricultural fields, construction sites, and developing urban areas. Practices such as no till farming and use of grassy swales can greatly reduce erosion from agricultural fields. Research has found that while forested land can naturally lose about 50 tons of soil per square mile per year, developing areas can lose 25,000 to 50,000 tons (USDAFS, 2003).

Soil erosion potential increases as the vegetative cover of trees and other plants decreases. Vegetation cover provides erosion protection mainly through dense, interconnected root systems. The roots of trees and other vegetation in forests bind soil particles at the ground's surface. Tree root systems extend beyond the canopy of the tree, protecting large areas of the forest floor, and extend vertically, serving to anchor soils well below the ground's surface (Wall, 2003).

In addition, trees and other forest vegetation protect highly erodable soils and prevent erosion by shielding soils from the direct impact of rain. Not only does this decrease the velocity of surface water runoff, but it also provides increased time for surface water to be absorbed by forest soils.

Map 7: Erodable Soils

Zoning

To gain an understanding of the development pressures facing the forest canopy cover located in Boone County, the zoning of the land with canopy cover was examined. To analyze the general trends, the zoning districts of Boone County were placed into seven categories: Agriculture and Low-Density Residential; Recreation; Conservation; Residential; Industrial and Office; Commercial; and Airport. Please refer to Appendix C for the list of each zoning district included in these categories. Table 8 shows the quantity of forest canopy cover and crown size based on the zoning district categories.

Table 8. Zoning Districts and Forest Canopy Cover Crown Size

Zoning District Category	Crown Size	Canopy Cover Area (acres)	Total Area (acres)	Percent
Commercial	Small	196	215	0.4%
	Medium	19		
	Large	0		
Conservation	Small	130	397	0.7%
	Medium	92		
	Large	175		
Airport	Small	491	624	1.1%
	Medium	116		
	Large	16		
Recreation	Small	1,081	1,762	3.0%
	Medium	563		
	Large	118		
Office/Industrial	Small	2,043	2,706	4.6%
	Medium	612		
	Large	50		
Residential	Small	2,305	3,107	5.2%
	Medium	662		
	Large	140		
Agriculture/Low-Density Residential	Small	32,885	50,574	85.2%
	Medium	15,321		
	Large	2,367		

These statistics reveal that approximately 4 percent of the county's forest resources are located in Recreation and Conservation zoning districts. Canopy cover located in these districts is not necessarily protected from deforestation. The purpose of the Recreation zoning district is to provide land for recreational activities and facilities. Land uses permitted in this zoning range from high-intensity development uses such as libraries, museums, and theaters, to outdoor recreational uses such as fairgrounds, golf courses, playgrounds, athletic fields, and passive recreational trails (Boone County Planning Commission, 2002).

Although the principle purpose of the Conservation zoning district is to identify, protect, and provide for the permanent green space, wildlife habitat, wetland protection, unique or rare species, neighborhood buffer areas, high visibility urban forests, and slope stability, some uses are conditionally permitted which could necessitate removal of trees. Conditionally permitted uses in the Conservation zoning district must be related to a principle permitted use (e.g., nature preserve, open space park, or historic site) and include: retail sales such as convenience stores, restaurants, and bed and breakfast establishments. The intensity of use in the Conservation zoning district, however, is based on the ability of the land to accommodate the uses without adversely impacting the natural character of the land (Boone County Planning Commission 2002).

Nearly 6 percent of the forest canopy cover is located in areas zoned for highly developed land uses such as commercial, office, industrial, and airport. Typically, these uses require mass grading and intense development of a site, precluding the preservation of trees and other natural features of the land.

The remainder of the canopy cover, over 90 percent, is located in the Residential and Agriculture/Low-Density Residential zoning districts. It is important to retain a high percentage of forest canopy cover in residential and agricultural land use areas as these uses contribute greatly to non-point source pollution in surface and groundwater resources. The preservation of existing trees and establishment of new trees in these areas can provide important public health and safety benefits to counteract the detrimental effects of residential and agricultural uses.

Contamination from residential and agricultural land uses typically includes the following.

- *Erosion and Soil Loss:* This is an issue in a number of areas across the region and can be caused by inappropriate or poorly timed cultivation, poor livestock management, and residential development projects.
- *Pesticides:* Surface and groundwater pollution from pesticides used on both residential and agricultural properties can be a problem due to leaching, run-off, drifting of spray into water, and/or spilling.
- *Fertilizers:* Chemical, organic, and even manure spreading applications in fertilizing lawns and fields can have drastic impacts on water quality.
- *Wastewater:* Septic systems are prevalent in the less developed portions of the County. Their age, condition, and system design can have important implications in the quality of water resources.

- *Livestock and pets:* Bacteria and viruses contained in urine and feces can contaminate water resources. Improperly located confined feeding operations and livestock pastures and improper disposal of pet wastes contributes to this problem.
- *Deforestation:* Removal of trees can increase erosion, degrade surface waters, increase the rate of siltation of bottom habitat in lakes, streams, and rivers, disrupt and alter hydrologic regime, decrease flow in dry periods, and allow increased concentrations of nutrients and pollutants to enter waterways.

Residential and agricultural properties are prominent throughout Boone County. Maintaining and increasing forest cover in these land use areas is critical to restore and improve the existing public health and safety benefits provided by forests.

Map 8: Zoning

Steep Slopes

Map 9 shows the percent slope in the forest canopy cover in Boone County. The total acreage of steep slopes (12 percent and greater) in the County is 41,332 acres. Of that amount, 27,502 acres have some form of consistent tree canopy cover on them, or 67 percent of the slopes. Currently, over 33 percent of the steep slopes in Boone County are without the protective cover of trees and other significant vegetation. Table 9 presents the acreage of slopes found within the county and their corresponding forest coverage.

Table 9. Steep Slopes in Boone County Forest Canopy Cover

Slope	Total Forested Area (acres)	Total Area in Boone County (acres)	Percent Forested
0 to 6 percent	10,782	74,308	15%
6 to 12 percent	21,111	48,829	43%
12 to 18 percent	19,786	29,815	66%
18 to 24 percent	6,172	9,185	67%
Greater than 24 percent	1,544	2,332	66%

In Boone County, many land development guidelines, regulations, and practices address erosion control and hillside stability based on soil type and slope. While soil types and classifications remain relatively unchallenged, slope categories can be grouped and defined in many ways. In Boone County, slope is often grouped in these ranges: 0 to 10 percent; 10 to 20 percent; and 20 percent and greater when considering land development plans. Usually restrictions are not placed upon a land use or activity unless the slope is equal to or greater than 20 percent.

For the purpose of this study, the 12 percent threshold was used to define the presence of steep slopes and as an indicator of where forests and other non-structural best management practices can have a great effect on slope stabilization. This is also generally the percent category used in soil surveys and Natural Resources Conservation Services publications.

Benefits of Trees on Steep Slopes

The presence or absence of vegetation cover on steep slopes, typically those greater than 12 percent, greatly affects the erosion potential and stability of the slope. Trees offer superior erosion control and bolster soil stability. It is considered a standard practice to maintain tree and/or vegetation coverage on slopes to protect the soil from erosion and dangerous slippage. Tree roots function in soil much like rebar in cement. They reinforce soils by increasing lateral soil shear strength and cohesion during saturated conditions. Furthermore, trees' complex root systems hold together large, deep blocks of soil that would normally be incapable of sustaining such great angles.

When development removes the protective vegetative cover, rainwater is able to strike the soils with greater force, dislodging soil particles; surface waters run unimpeded. The loss of this vegetative buttress on steep terrain increases soil instability and the risk of erosion. The weight of the water that saturates the unprotected soils can combine with the force of water flowing over their surface to cause catastrophic slope failure. In this respect, trees help protect manmade structures from damage and safeguard human lives.

Vegetation on steep slopes can also improve water quality. Waterways are common features at the bases of steep slopes. Vegetation growing on these slopes, especially trees, reduces the velocity of stormwater entering the drainageways—both in slowing sheetflow and in facilitating infiltration. Trees can help reduce the frequency and severity of flash flooding and reduce the amount of sediments and harmful pollutants eroding into the waterways.

Map 9: Slopes

Impervious Surfaces

Large areas of impervious surfaces are significant sources of non-point source pollution. Stormwater flowing across roads and parking lots collects petroleum products, sediment, heavy metals, nutrients, animal waste, and other contaminants. In addition, as the percentage of impervious surfaces increases in a watershed, increased runoff quantities and decreased stormwater abatement results in additional flooding and erosion downstream.

To identify general locations that might generate non-point source pollution, impervious surface data were compiled by combining the developed areas identified by the US Geological Survey National Land Cover Data (USGS, 1992) with roads data. The impervious areas of roadways were assigned based on their functional classification as follows: 30 feet for local roads; 70 feet for arterials; and 100 feet for highways. The impervious surfaces identified in Boone County are shown in Map 10.

Using this method to develop these data, 8,567 acres of impervious surfaces were mapped in Boone County. This is approximately five percent of the County (Table 10).

Table 10. Boone County Impervious Surfaces

	Area (acres)	Percent of County
Boone County	164,469	
Impervious Surfaces	8,567	5%

Benefits of Trees in Reducing the Negative Effects of Impervious Surfaces

As the area of impervious surfaces increases, the volume of stormwater runoff will also increase, carrying increased quantity of stormwater downstream. Stormwater management is a growing concern in Boone County. Unmanaged stormwater contributes to severe flooding and water pollution, which threatens public health and safety on many levels. Although man-made, structural devices are the standard practices used to manage stormwater, the forest cover of the county provides valuable stormwater control functions that are often overlooked.

Forest vegetation occurs in layers; the top layer consists of mature trees with immature trees and shrubs in the middle and smaller plants and groundcover at the bottom. This vegetative system creates a vertical, structural zone that provides a tremendous amount of leaf and woody surface area that can collect and slow down rainwater during storms, much more than a farm field or developed area. Figure 3 shows slightly more than 40 percent of rainfall is intercepted by forests.

During storms, up to 25 percent of the total rainfall is intercepted by trees as water adheres to leaves, branches, and bark. Rather than directly flowing into streams and rivers where it would increase flooding, much of this water returns to the atmosphere by evaporation. Forests also decrease runoff and avert flooding by capturing water in depressions and irregular areas on the forest floor. In this way, because of their irregular ground surface, forests generally have a greater capacity to store water than agricultural or developed areas, which have smooth and graded surfaces.

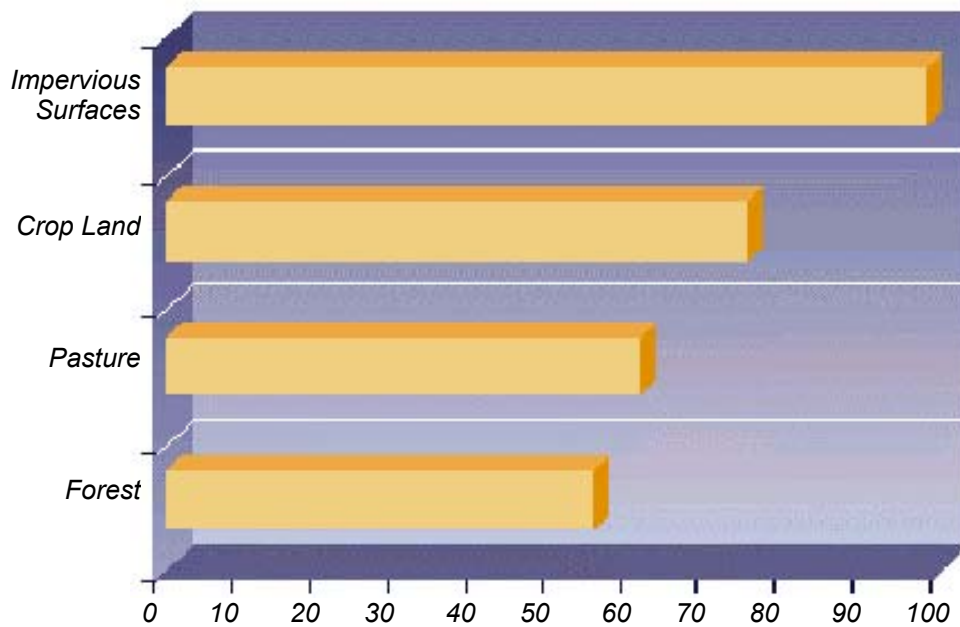


Figure 3. Percent of precipitation that runs off land based on land cover type (Vermont Agency of Natural Resources, 1999).

To the extent possible, the County and local jurisdictions should encourage the occurrence of *run-on*. Run-off is defined as the direction of stormwater flow from pervious cover to impervious cover (e.g., sloping lawn to paved road); whereas, run-on is the flow of stormwater from impervious cover to pervious cover. If sites are graded to produce run-on, water is much more likely to infiltrate the soil and reduce stormwater runoff. Some examples of stormwater run-on include:

- Roof top discharge that travels through downspouts and across forests or other vegetated areas;
- Road drainage that is directed into forested or grassed swales rather than curbs and gutters;
- Parking lots that drain into forests or other vegetated areas; and
- Isolated sidewalks and bike paths where stormwater is directed to adjacent forests or other vegetated areas.

Map 10: Impervious Surfaces

Critical Areas Assessment

The forests in Boone County provide many public health and safety benefits; however, forest cover does not universally provide equal benefits. For instance, forests located on a gentle slope far from a waterbody would not provide the same benefits as forests on steep slopes adjacent to a major stream.

To determine the locations of forest cover that provide the most critical public health and safety functions requires the expertise of natural resource scientists using Geographic Information Systems (GIS) technology. Davey developed a scoring system to evaluate public health and safety issues related to environmental functions of trees. The following metrics were used:

- Presence of steep slopes and highly erodable soils;
- Flooding mitigation;
- Buffering capacity to protect water quality; and
- Groundwater contamination sensitivity.

Tree crown size was not used in the development of the scoring system. The crown size classifications developed for Boone County forest canopy cover show the relative measure of the ecological integrity, health, and age of a stand of trees; therefore, it is not applicable to the public health and safety functions of this study.

Davey's foresters, arborists, ecologists, biologists, and GIS specialists developed a scientific scoring system to assess, locate, and measure the canopy cover in Boone County and assign relative public health and safety values. Using this scoring system, specific countywide land characteristics and forest cover are given numeric ratings depending on the impact they have on public health and safety issues. The individual GIS layers are overlaid with the forest canopy cover data to discover critical *intersections*. Where many intersections occur, or intersections of highly ranked criteria, the highest levels of public health and safety benefits are provided by the forest. Conversely, where there are few intersections, the forests, although still providing critical public health and safety functions, are providing fewer benefits.

To evaluate public health and safety issues related to forest canopy functions in Boone County, the following metrics were analyzed:

- Steepness of slope to examine erosion hazard slope stabilization;
- Location within the floodplain to examine flood abatement, water quality and quantity;
- Riparian buffers to identify areas with the capacity to protect water quality; and,
- Groundwater sensitivity to measure pollution potential.

The ***Steep slopes*** variable evaluates the relationship between erosion potential and slope stabilization based on the forest cover of an area. The value of forests for preventing erosion and stabilizing slopes is greatest in areas of steep slopes—those approximately 12 percent or greater. To account for the greater benefits trees located on steep slopes provide, the following scores were assigned based on the percent of the slope:

- 1 — less than 6 percent;
- 2 — 6 to 11 percent;
- 3 — 12 to 17 percent;
- 4 — 18 to 24 percent; and
- 5 — greater than 24 percent.

The ***Floodplains*** variable evaluates the relationship between flooding potential, water quality, and forest cover. The value of forests for mitigating flooding and contributing to water quality by preventing or filtering soilborne pollutants is well documented. Therefore, simply, trees located within the floodplains are more valuable than those that are not. Scores were assigned based on the following factors:

- 0 — out of the 100-year floodplain; and
- 1 — in the 100-year floodplain.

The ***Riparian zone*** variable evaluates the relationship between stormwater mitigation, water pollution, and forest cover. The value of forests for mitigating stormwater and protecting water quality by reducing and filtering airborne and soilborne pollutants is well documented. Therefore, simply, riparian areas with forest cover are more valuable than those that are not. The riparian zone was defined as the region within 300 feet of a watercourse. In addition, in areas where the floodplain of a watercourse extended beyond 300 feet of the watercourse, the floodplain area was also included in the riparian zone. Scores were assigned based on the following factors:

- 0 — out of the riparian zone; and
- 1 — in the riparian zone.

The ***Groundwater sensitivity*** variable evaluates the relationship between geology, groundwater pollution, and forest cover. The value of forests for protecting and enhancing groundwater recharge areas and improving water quality by reducing and filtering soilborne pollutants is well documented. Therefore, areas of groundwater sources with high sensitivity ratings with forest cover are more valuable than those that are not. A rating of low sensitivity indicates that groundwater is naturally well protected from surface contaminants, although not necessarily immune from long-term pollution. High sensitivity ratings indicate that, in general, groundwater could be easily and quickly impacted by surface activities.

- 1 — areas with a sensitivity score of 2;
- 2 — areas with a sensitivity score of 3; and
- 3 — areas with a sensitivity score of 4.

Using these public health and safety categories and the metrics assigned to each one, a forest area could be ultimately scored from the lowest rating of 2 to the highest rating of 9. Table 13 shows the results of applying the public health and safety matrix to the Boone County forest canopy cover.

Table 13. Critical Areas and Forest Canopy Cover Crown Size

Score	Crown Size	Area (acres)	Total Area (acres)	Percent of Total Canopy
Less than 3	Large	1,300	33,708	57%
	Medium	8,559		
	Small	23,848		
4 and 5	Large	1,190	22,308	38%
	Medium	7,253		
	Small	13,864		
Greater than 6	Large	370	3,289	6%
	Medium	1,557		
	Small	1,362		

All of the forest cover in Boone County provides valuable public health and safety benefits. Some areas provide only one of the benefits analyzed while others provide multiple benefits. Table 13 suggests that 57 percent of Boone County’s forest cover is in areas that provide single benefits, such as protecting surface waters from siltation and pollution or protecting highly sensitive groundwater. These singular functions of the forest canopy can dramatically improve the quality of life and protect public health and safety for the citizens of Boone County. These singular functions can also save Boone County from spending public funds to correct and mitigate pollution and erosion problems.

However, nearly 44 percent of County forests are located on areas that provide multiple public health and safety benefits. Of particular note is that 3,289 acres of forest cover are providing multiple public health and safety benefits, and these critically sensitive areas should be regarded as environmentally constrained.

Map 11 shows the results of the critical areas assessment of Boone County forest canopy cover. The most critical areas identified provide the most benefits of the tree canopy based on their location in floodplains, riparian areas, highly sensitive groundwater regions, and/or steep slopes. The majority of the high-ranking critical areas—scoring greater than 6 and shown in red on Map 11—are located in the northern and western portions of Boone County. These critically sensitive areas are primarily located close to the Ohio River and along the highly sensitive small headwater streams that feed into main tributaries of the Ohio River.

Medium ranking areas score either 4 or 5 and are shown in orange on Map 11. They are typically located within the riparian zones on steep slopes, and in sensitive groundwater regions.

Low-ranking critical areas—scoring 3 or lower and shown in yellow on Map 11—were identified throughout the County; these areas are typically located within a riparian area. These low-ranking areas should provide a focus for preservation of existing forest resources in Boone County based on the high quantity of public health and safety benefits these areas provide.

Although these medium and low ranking areas provide less public health and safety benefits to Boone County, deforestation of these areas would lead to an overall decrease in the benefits that the County receives due to its forests.

The critical areas assessment scores can be used to prioritize areas for protection based on the benefits the trees provide to the County. The most critical areas provide the greatest quantity of benefits; therefore, efforts to protect these forested areas should be a high priority. In addition, these data provide a baseline of the canopy cover benefits in Boone County. Future studies can be performed to identify areas where efforts to protect and enhance forest canopy cover have succeed or failed.

Map 11: Critical Areas Assessment

Recommendations

The forest canopy cover of Boone County performs and provides many public health and safety benefits for all residents. The forests are providing these benefits now, and will contribute even more in the future, as the small and medium crown forests grow into large crown forests. Generally, this study suggests that these actions be considered:

- The existing forest, especially in the critical areas, should be protected;
- The forest cover in all other areas should be evaluated before future development occurs, but could be reduced to facilitate economic development of the county;
- Guidelines should be established for the evaluation process of development proposals in the forested areas; they should be consistently used and applied throughout the County; and
- Areas with no forest cover, especially in critical areas of steep slopes and riparian corridors, should be evaluated and reforestation plans should be created and implemented.

In addition, Boone County can use and promote existing mechanisms to increase the benefits provided by forests. For example, the Kentucky General Assembly passed the Agricultural Water Quality Act that requires the development and implementation of a water quality plan for areas greater than ten acres used for cultural purposes. The landowner must develop this plan; support and guidance for the plan can be obtained from the Kentucky Agriculture Water Plan. The goal of the Act is to protect surface and groundwater resources from pollution resulting from agricultural and silvicultural land uses. This existing mechanism is a useful tool for managing forests to further enhance the public health and safety benefits they provide.

The following recommendations are suggestions for action-items to protect and enhance the existing forest cover and to establish forest cover where it is needed. The recommendations range from a variety of planning and management tools to simple public education. They are suggested as realistic and practical goals for the Council, County, municipalities, and citizens to achieve.

Legislation

Enacting laws and making public prohibitions is not a popular way of influencing behavior; however, sometimes an issue is so important and complex, that legislation is an appropriate tool for local governments to use to protect natural resources. Various types of legislation can be particularly effective in protecting natural resources since the very nature and location of these resources often cross public and private lines, and the presence or absence of them in a community can greatly affect the community and surrounding area as well.

Tree Ordinances

One of the more effective tools used by communities to conserve and improve their urban and community forests are tree ordinances. Tree ordinances may address issues from simple tree replacement standards to more comprehensive ordinances to address natural resource issues. It is recommended that Boone County and the municipalities within the county enact or strengthen existing ordinances to protect and enhance the forest canopy within their respective jurisdictions.

A tree ordinance contains the legal provisions adopted by the local governments to provide authority, define responsibility, offer guidance to residents, and establish minimum standards for a community's tree program. An individualized tree ordinance should be developed for each community; one ordinance does not fit all local situations. A tree ordinance encourages tree planting and tree maintenance to secure the beautification, air-cooling and purification, noise abatement, property value enhancement, wildlife habitat, and other public health and safety benefits trees provide.

Tree ordinances are important for many reasons and serve many purposes, including:

- Provides permanent procedures and legal authority;
- Establishes an official policy for the community;
- Identifies standards and regulations for arboricultural practices such as planting, removal, maintenance, and selection of appropriate tree species for the community's trees;
- Makes the community's tree management program more visible;
- Establishes a program independent of changing public opinion and finances;
- Helps establish new tree management programs;
- Provides a channel through which governmental departments may interact;
- Establishes the nature and degree of public responsibilities to the community's trees according to specific standards; and
- Provides the means to educate the public about the benefits of the community forest (Ricard, 2002).

Generally, simple tree ordinances guide the management of public trees. They address issues such as proper planting, maintenance, liability, and responsibility. They also act as a solid example of how the entire community and citizens should manage the trees under their control. Tree ordinances can protect the valuable natural resource of the urban forest and ensure that it is protected to provide public health and safety as well as many other important benefits.

Tree Preservation Ordinances

Tree preservation ordinances expand on the general principles and goals of the simple tree ordinances by addressing larger issues such as protection of trees on private property, protection of trees in critical areas (*e.g.*, streambanks), and protection of unique forest ecosystem areas.

The goals of tree preservation ordinances can include:

- Reducing tree loss during development;
- Reducing damage to standing trees during construction;
- Providing for replacement of trees lost during construction;
- Providing for planting trees where none occurred previously; and
- Providing for the maintenance of preserved trees after construction is completed.

The ordinance may address only projects undertaken by governments and/or on public lands or the scope may be expanded to include private projects such as residential, commercial, and industrial developments. The ordinance may also specify minimum size for a project to be regulated, measured in land area or in project cost. In addition to regulating tree preservation, tree replacement and planting may also be addressed (Buck, 1997).

Several approaches can be used to define the preservation of trees within a development. For example, the ordinance in Cold Spring, Kentucky, uses a minimum basal area to ensure a minimum canopy cover for all land within the municipality. Other ordinances establish a maximum percentage of trees that can be lost due to development. Another approach is to require that the post-development forest be proportionally similar to the pre-development forest.

Tree replacement guidelines may also be included in the ordinance. For example, some ordinances permit replacing fifteen 2-inch diameter trees for the removal of one 30-inch diameter tree. This can become a complex procedure and may fail to mitigate the loss of a mature forest if there is not a mechanism to ensure the survival of these newly planted trees. In addition, it may be challenging to locate appropriate planting sites for large numbers of small trees.

In Boone County, an ordinance should be developed that creates incentives to achieve compliance. For example, preserved trees may be credited to the landscaping typically required on a project. The intent of a tree preservation ordinance should be to provide incentives for projects that complement the existing forests and replace excessive tree loss.

Riparian Setbacks and Easements

Retaining undisturbed, forested land along sensitive resources such as streams and rivers provides additional measures of protection. Undisturbed vegetation along streams and rivers filters pollutants, abates flooding, allows for groundwater infiltration of stormwater, reduces erosion and sedimentation, stabilizes banks, and provides habitat benefits. These areas may be protected by setbacks from the resource area similar to lot-line setbacks. Setbacks protect property owners by preventing construction too close to flood- or erosion-prone areas that widen due to upstream development.

Requiring riparian setbacks and easements prevents development of the most sensitive lands and promotes a reduction in flooding, erosion, and water quality problems while creating more attractive, livable communities. Boone County currently has no ordinance for a riparian setback.

An example of a riparian setback ordinance in Summit County, Ohio, is based on the size of the watershed and the presence of steep slopes. This ordinance establishes:

1. A minimum setback of 300 feet on each side of all watercourses draining an area greater than 300 square miles;
2. A minimum setback of 120 feet on each side of all watercourses draining an area greater than 20 square miles and up to 300 square miles;
3. A minimum setback of 75 feet on each side of all watercourses draining an area greater than ½ square mile and up to 20 square miles; and
4. A minimum setback of 50 feet on each side of all watercourses draining an area less than ½ square mile with a defined channel and bank area.

In addition to the minimum setbacks, the ordinance addresses the need to increase the setback width based on the presence of steep slopes and floodplains adjacent to a watercourse. Where the 100-year floodplain is wider than the riparian setback on either or both sides of the watercourse, the riparian setback should extend to the outer edge of the 100-year floodplain. Because the gradient of the riparian corridor significantly influences impacts on the stream, the width of the riparian setback increases based on the average percent slope as identified in Table 14.

Table 14. Increasing Riparian Setbacks Based on Steep Slopes

Average Percent Slope	Width of Setback
15% to 20%	Add 25 feet
21% to 25%	Add 50 feet
Greater than 25%	Add 100 feet

Conservation Development

Conventional development carves the landscape into a patchwork of disturbed (*i.e.*, mowed, graded, and paved) land. Conservation development or open space subdivisions are designed to create the same overall density while preserving 50 percent or more of the site in open space by grouping buildings together on smaller lots than would ordinarily be allowed under standard zoning or by having flexible side, rear, and front yard setbacks. The critical areas of Boone County forest canopy cover identified in this study can be preserved and protected within the open spaces in conservation developments.

Although Boone County does provide for conservation developments, none have yet to be designed or built. Conservation development is a valuable tool for protecting important natural resources and constrained areas as identified in this study. Important considerations further promote conservation development in Boone County include the following:

1. Educating local officials and the development community as to the value, public health and safety benefits, and mechanics of conservation development;
2. Educating the public as to the benefits of and need for conservation development; and
3. Identifying linked systems of resources to protect and areas for relatively dense development by comprehensive planning.

Conservation Easements and Land Donations

Not all forest protection and preservation efforts need to be legislative, expensive, or seen as a violation of private property rights. Often, property owners will willingly donate all or portions of their property to governments or non-profit organizations for forest and farmland preservation. Other than the outright donation of property, owners can also allow and approve conservation easements to be placed on their property. A conservation easement is a voluntary agreement that allows a landowner to permanently limit the type and amount of development on their property while retaining private ownership.

All parties concerned in transactions relating to conservation easements and land donations generally regard these actions positively. There is no ‘taking’ by the government; the community benefits from the additional protected greenspace; and the property owner can receive financial as well as non-financial benefits from the donation or easement transaction.

The Boone County Conservancy is a local organization that can prepare, accept, hold, and manage conservation easements and accept land donations. However, the County, municipalities, and national organizations, such as The Land Trust and the Nature Conservancy, can also accept donations and easements of forests and open space.

Using the findings of the *Boone County Forest Quality Assessment Study* and the information provided from the *Public Health and Safety Functions Analysis*, the Council can work cooperatively with local organizations to educate and encourage the landowners in the County to consider donating or placing conservation easements on their land to protect critical forest areas.

Management Tools

Tree Inventories

A tree inventory is the gathering of accurate information on the health and diversity of the individual trees in a community forest. An inventory provides data concerning the number of trees, the condition of trees, and the types of trees present in a community. Tree inventories are an essential tool of good management and can ultimately protect and enhance urban and community forests.

The inventory may be used to:

- Determine the need for a community forestry program. For example, if the inventory reveals many dead and diseased trees, a high percentage of one or more species, or areas that have no trees, this suggests that a management program that incorporates tree planting is needed.
- Prioritize maintenance schedules in order to reduce the potential liability that results from hazardous trees. It also streamlines the efficiency of work performed and facilitates long-term budgeting.
- Educate residents about the benefits of a healthy, well-managed community forest, and inform them about species best suited to the community.
- Facilitate the planning that is essential to the community's quality of life.
- Provide the basis for the development of a comprehensive community forestry management plan (USDAFS, 2003).

Generally, information on the following is collected: species, size, condition, maintenance, site characteristics, planting spaces, utilities, and other unique data based on the community's needs. A tree inventory provides valuable data on forest composition, age, and quality, which can help determine if the maximum public health and benefits are being realized from the existing urban forest. These data may be used to manage the urban forest with or without a formal management plan.

Forest Canopy Inventories

Forest canopy inventories differ from basic tree inventories in that the primary focus is on larger, contiguous tracts of woodlands rather than on individual trees. This type of inventory has already been performed in Boone County. GIS data were developed and a written report was prepared analyzing these data.

This inventory should be updated at least every five to ten years. The information that exists currently can be used as baseline data upon which future forestry canopy studies can be compared to determine success or failure of protecting and enhancing the forest cover in Boone County.

Urban Forest Management Plans

The development of an urban street and park tree management plan is an important tool in managing community forests and should be the first step in the process of protecting urban trees and forest areas throughout the developed portions of Boone County. Without a management plan, the governments and individuals responsible for taking care of urban and suburban forests will not be effective in meeting the true needs of the trees. A management plan establishes a clear set of priorities and objectives related to the goal of maintaining a productive and beneficial community forest.

Municipalities generally develop these management plans for community forests. They can not only prescribe planting and maintenance plans for street tree, but can also suggest management for park land, open space, and true forest ecosystems within the corporate limits.

The existence of a management plan in a community indicates a high level of commitment to protecting trees, and it indicates a higher level of education and knowledge about natural resource issues in general. The benefits of trees can be maximized when both professional management resources and an educated public coexist.

Countywide Forest Management Plans

In Boone County, the vast majority of the population lives in the urban or suburban environment; these areas are expanding at a high rate. Therefore, the need for the County to develop a plan to manage the remaining forest resources is becoming increasingly important. The remaining fragments of undeveloped open space, forest tracts, parklands, and landscape trees on both public and private property all comprise the County's forest. Together, all of these rural and urban forest tracts are linked. It is important to properly manage these forest areas to maintain their health in order to derive the maximum benefit for human life.

Currently, a comprehensive, county-specific, guide for the owners of these forested tracts—private property owners, farmers, commercial businesses, homeowners associations, community associations, or property management companies—is unavailable. Forest management is either performed on an as-needed basis, possibly incorrectly, or not at all.

To partially address this issue, the Kentucky Division of Forestry provides staff and resources to Boone County. The County should formalize this assistance and work with the Division of Forestry to create, at least, forest management guidelines and plans that would protect and enhance the forest areas. By providing a consistent management philosophy, it is the hope that the outcome will be a healthier forest and human community.

In addition to using the available staff from the Division of Forestry, Boone County should consider developing forest management plans. These plans should focus on re-establishing forests to increase forest resources and canopy cover and preserving and maintaining the existing community forests.

The key to growing and maintaining a healthy county forest is to involve the whole community and to pursue those individuals or groups that will help attain these goals. Creating a comprehensive county forest management plan could be an opportunity to create new partners and strengthen existing relationships.

Boone County already has the main ingredients for creating a countywide forest management plan: a forest canopy inventory; a comprehensive plan; and citizen-based advisory boards. The next step would be to develop a comprehensive Forest Management Plan that establishes recommendations, implementation actions, and schedules to achieve the County's stated goals for the program. The plan should also include how the stated goals will be achieved within the confines of budgets, available resources, related county ordinances and policies, and a list of program priorities for the long-term management of the county's forest.

The final plan should be ecologically based, economically feasible, dynamic, and flexible enough to allow updates in response to any changes in environmental conditions and Boone County's needs.

Reforestation

One of the main benefits of the forest canopy inventory is to identify areas in Boone County lacking trees. Areas near floodplains, within riparian corridors, on steep slopes, and over sensitive groundwater areas can be readily located, measured, and ownership determined. Using this information, critical areas needing reforestation can be determined and prioritized.

It is recommended that potential reforestation areas be located and prioritized as soon as possible. Financial and forestry resources are available from other public agencies and private organizations to implement reforestation projects. To take advantage of these resources, a countywide tree planting plan, or reforestation plan, should be created.

Street tree planting, landscaping, reforestation, or riparian restoration projects all require some knowledge of what to plant, where to buy, and how to plant them. A tree planting plan establishes a program for planning and creating a community that is attractive and is environmentally functional. The planting plan is necessary to establish a logical schedule to achieve the community's reforestation goals.

Open Space and Greenways Planning

Developing a plan for potential parks and open space resources is important to allow greenways and other open space to be preserved or developed for recreation incrementally as funds become available for land purchase or land is set aside through other means. A greenways plan should use environmental constraints to identify the most important lands to protect, as well as to determine the type of recreation or open space that should occur there. For instance, where areas of critical tree canopy have been identified, it may be advisable to restrict use of the open space.

Areas with numerous resources in rapidly developing communities may also be important to secure from development. An open space and greenway plan should be expanded to include additional land in riparian corridors, especially where numerous resources occur together and provide multiple benefits to the community, such as the critical canopy cover areas identified in this study.

It is important to establish linked systems of forests and open space to maximize the multiple benefits of contiguous natural vegetation cover. Trail systems should be linked to provide transportation between community facilities and regional trails. By mapping preferred open spaces, Boone County, local communities, land conservancies, and even developers, can focus on setting aside or purchasing the lands that provide the most value in terms of resource protection and linked greenways.

Educational Tools

An important element of any successful rural or urban forestry program in any community is education. Governments and non-profits alike can work together to educate and inform property owners how to maintain their trees and forests, plant trees, and engage in development projects in ways that protect existing forest tracts.

The educational tools discussed in this section are proven approaches to protect urban and community forests. Implementing any of the recommendations previously described will require a substantial effort, and education and information dissemination are critical to the success of these efforts. A successful county wide educational program should illustrate two important principles:

1. Forests and the natural resources within them provide numerous public health and safety benefits, positively affect property values, and increase the quality of life in the county for both citizens and businesses; and
2. Development can be managed to allow for a variety of uses of property while protecting the most important natural resources.

Implementing any of the above resource protection measures will require educating public officials and developers in designing, implementing, and complying with the new requirements in a way that appropriately protects the resources while allowing use of the land. The measures discussed above involve changing perceptions about many issues, including:

1. Natural resources provide public and private health and safety benefits and are natural mechanisms to reduce many countywide problems. Trees and forests are not just attractive areas for humans and places for animals to live; they are Boone County's natural heritage.
2. Natural resources can be protected through both regulation and guidance. Not all forest protection strategies have to be legislated. Incentives and education can greatly promote proper forest stewardship across the county.
3. All activities have some level of impact on our natural resources and Boone County residents have a personal responsibility to help protect their resources.

The Council and allied partners should take a leadership role in the educational efforts in Boone County. The Council as a non-partisan organization, and with its access to current and comprehensive forest data, is the natural and neutral agency to effect change.

The education topics of the Council's efforts should range from the scientific data of the Boone County Forest Canopy Assessment projects to more basic, consumer-oriented tree care, planting, and benefits information. The educational efforts should be offered to the following persons and groups:

- City Planners
- Engineers
- Building Inspectors
- City Advisory Commissions
- Contractors/Subcontractors
- Home/Property Owners
- Neighborhood Associations
- Foresters
- Citizen Groups
- City Councils
- Utility Companies
- Realtors
- Developers
- Landscape Architects

Educational tools may include:

- *Workshops and training seminars* with community leaders, advisory groups, contractors, homebuilders, and county and municipal staff.
- *Publications*, including direct mailings, newsletters, forestry and arboricultural handouts, landmark, unique and historic tree brochures, special publications (such as the *Woodscaping* booklet), and articles for the local print media. These publications should be available in electronic format and included on the Council's website.
- *Awards and events* to recognize contractors and governments who excel at tree preservation and reforestation, and countywide Big Tree Contests and Arbor Day events and programs.

Conclusion

Tree and forest protection, enhancement, and preservation are emerging environmental issues as communities also address concerns involving wetlands, floodplains, stormwater, water quality, steep slopes, and air quality. New construction and development often lead to tree and forest loss. Remaining trees and forests lose vigor because of changes made and damage sustained during construction. The Council should assist Boone County and all other county and regional allied organizations to consider and develop programs and policies to protect, support, and expand Boone County's urban forests and undisturbed woodland resources.

The Council should help Boone County recognize the importance of protecting natural resources to safeguard public health and safety, provide recreational opportunities, and enhance the livability of the County. The following key issues outlined in Table 15 have been identified through the public health and safety benefits analysis, and are provided to the Council for consideration and appropriate action.

Table 15. Key Issues and Recommendations

Key Issues	Rationale	Recommendations
Protection of Riparian Corridors	To protect steep slopes and critical habitat, improve water quality, and reduce flooding.	<ul style="list-style-type: none"> • Encourage stream bank tree planting and acquire riparian easements • Protect remaining vegetated riparian corridors and revegetate or restore impacted riparian corridors • Consider adopting riparian setbacks
Protection of Steep Slopes	To protect steep slopes, improve water quality, reduce downstream flooding, reduce erosion, and protect homeowners.	<ul style="list-style-type: none"> • Protect remaining vegetated slopes over 12 percent • Revegetate steep slopes • Enact guidelines or regulations that limit tree removal on steep slopes
Protection of Groundwater Resources	To protect sensitive groundwater resources.	<ul style="list-style-type: none"> • Protect current forests over critical groundwater areas • Reforest sensitive areas
Protection of Floodplains	To enhance the benefits and protection of property forested floodplains provide.	<ul style="list-style-type: none"> • Protect current forests in floodplains • Reforest floodplain areas without canopy cover
Protection of Urban and Community Forests	To protect existing canopy cover that provides numerous public health and safety benefits.	<ul style="list-style-type: none"> • Develop tree and tree preservation ordinances within the incorporated areas of the county and for the county • Provide incentives for tree preservation on private property during development • Encourage the County and cities to allocate more funding to forestry program or explore alternative methods of funding these activities • Educate the public on forestry and arboricultural topics • Facilitate the process for obtaining conservation easements and promote land donations • Encourage the use of conservation development • Include the forest canopy data in all planning efforts

Table 15 (Continued). Key Issues and Recommendations

Key Issues	Rationale	Recommendations
<p>Management of Existing Forest Resources</p>	<p>To provide greater benefits and maximize resources by establishing proper and professional management of forest resources</p>	<ul style="list-style-type: none"> • Maintain and update the countywide forest canopy inventory and encourage inventories of public trees • Consult with the State Division of Forestry to create forest management plans and guidelines • Encourage municipalities to create and adopt management plans for their public trees and forests • Develop and maintain County and municipal urban forestry boards that are active in tree planting, maintenance projects, and public education
<p>Reforestation of Critical Areas of the County</p>	<p>To provide and guarantee continued benefits of future canopy cover</p>	<ul style="list-style-type: none"> • Prioritize critical areas of the county without adequate forest cover • Target key forest resources for acquisition or protection • Develop planting and reforestation plans and programs for private and public properties without adequate forest cover • Provide incentives for tree planting during development and reforestation of agricultural lands
<p>Education</p>	<p>To promote the acceptance and implementation of forest protection guidelines and regulations</p>	<ul style="list-style-type: none"> • Prepare new educational materials and organize existing information on forest and tree related topics • Disseminate educational information to target groups and individuals on a regular basis • Create and sponsor public awareness events • Encourage communities to become a Tree City USA—a program of the National Arbor Day Foundation

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Appendix B

Highly Erodable Soils

Code	Soil Description
AID	Alluvial Land
BrC	Brashear Silty Clay Loam
BrD	Brashear Silty Clay Loam
BsD3	Brashear Silty Clay
ChC	Chavies Fine Sandy Loam
CyD	Cynthiana Flaggy Silty Clay Loam
CyF	Cynthiana Flaggy Silty Clay Loam
EdD2	Eden Silty Clay Loam
EdE2	Eden Silty Clay Loam
FcC	Faywood Silty Clay Loam
FcD	Faywood Silty Clay Loam
FdD3	Faywood Silty Clay
Gu	Gullied Land
JeB	Jessup Silt Loam
JeC	Jessup Silt Loam
JeD	Jessup Silt Loam
JeE	Jessup Silt Loam
JsD3	Jessup Silty Clay Loam
LkB	Licking Silt Loam
LIC	Licking Silty Clay Loam
LID	Licking Silty Clay Loam
NeC	Negley Silt Loam
NeD	Negley Silt Loam
NIB	Nicholson Silt Loam
NIC	Nicholson Silt Loam
RsC	Rossmoyne Silt Loam
WhC	Wheeling Silt Loam
WoC	Woolper Silty Clay Loam
WoD	Woolper Silty Clay Loam

Appendix C

Boone County Zone Districts

The **Agriculture and Low-Density Residential** category is composed of the following zoning districts:

- Agriculture (A-1)
- Agriculture Estate (A-2)
- Rural Suburban Estates (RSE)
- Rural Suburban (RS)

The **Residential** category is composed of the following zoning districts:

- Suburban Residential One (SR-1)
- Residential One Family (R-1F)
- Mobile Home Park (MHP)
- Suburban Residential Two (SR-2)
- Suburban Residential Three (SR-3)
- Urban Residential One (UR-1)
- Urban Residential Two (UR-2)
- Urban Residential Three (UR-3)

The **Commercial** category is composed of the following zoning districts:

- Commercial One (C-1)
- Commercial Two (C-2)
- Commercial Services (C-3)
- Commercial Four (C-4)
- Walton Downtown District (WD)
- Union Town Center (UTC)
- Union Commercial (UC)
- Union Neighborhood Office (UNO)

The **Office and Industrial** category is composed of the following zoning districts:

- Office One (O-1)
- Office Two (O-2)
- Industrial One (I-1)
- Industrial Two (I-2)
- Industrial Three, Surface Mining District (I-3)
- Professional Office One (O-1A)
- Industrial Four, Subsurface Mining District (I-4)
- Public Facilities District (PF)
- Employment Planned Development District (EPD)

The **Airport, Conservation, and Recreation** categories are composed of the Airport (A), Conservation (C), and Recreation (R) zoning districts, respectively.

Appendix D

Davey Resource Group Personnel Profiles

Project Manager: Jennifer L. Gulick, M.A., is a business developer and project manager with Davey Resource Group. She has over 20 years of experience in managing urban forestry, land management, and natural resource programs. She is a certified arborist and a certified forester. She is president of the Ohio Chapter of the International Society of Arboriculture and president of the Greater Cincinnati Professional Grounds Management Society, as well as serving on the advisory boards of several other professional organizations. Ms. Gulick holds a Bachelor of Science degree in forest resource management from West Virginia University and a Master of Arts degree in public administration from the University of Cincinnati.

Ana Burns, M.S.E.S., is a biologist responsible for project management, data analysis, and report writing for ecological surveys, watershed studies, park inventories, and other large-scale projects. She has experience in wetlands delineations, lake and watershed management, and forestry. In addition, Ms. Burns has extensive knowledge of aerial photograph interpretation and geographic information systems (GIS). She joined Davey Resource Group after working as an environmental planner for a county planning department. In this position, she gained valuable experience in facilitating public participation meetings, developing educational outreach materials, and assisting the Planning Commission and their subcommittees in implementing and enforcing comprehensive plans and zoning ordinances. Ms. Burns graduated from Indiana University, Bloomington, with a Bachelor of Science degree in biology, and holds a Master of Science degree in environmental science from IU's School of Public and Environmental Affairs.

Michael R. Binkley, M.A., has seven years of experience and education with the implementation of GIS for environmental analysis and natural resource management, from data acquisition and database creation, to sophisticated spatial analysis and decision-making. Possessing extensive knowledge of the major GIS software packages currently in use as well as the operating systems and platforms on which they are typically based, Mr. Binkley currently supervises GIS operations at Davey. He is also an experienced programmer with emphasis on Visual Basic and GIS programming languages. Mr. Binkley holds a bachelor's degree in Conservation of Natural Resources and a master's degree in Geography from Kent State University.

Todd A. Crandall, M.En., is a wetlands scientist that routinely performs wetlands assessments and delineations, and prepares restoration and mitigation plans. He also performs vegetation cover mapping and plant identification via orthophotograph interpretation. He is certified for wetlands studies by the U.S. Army Wetlands Delineator Certification Program, and is a certified Professional Wetlands Scientist (PWS) through the Society of Wetland Scientists. He has completed the 40-hour OSHA health and safety training (OSHA Standard 29 CFR 1910.120). He has 10 years of experience and holds a bachelor's degree from Hiram College in biology and a master's degree in environmental science from Miami University.

Jessica Hickey, M.S., is a biologist that assists in ecological surveys, wetland delineation and mitigation projects, environmental site assessments, data analysis, and report writing. She has experience in a wide variety of environmental and biological projects including wetland delineation and mitigation; plant, fish, macroinvertebrate, reptile, amphibian, and bird surveys; and water quality testing. In addition, she has worked under contract for the government composing Environmental Assessments and Environmental Impact Statements to fulfill National Environmental Protection Act (NEPA) requirements. In this position, she gained insight by attending planning meetings, working with engineers and planners to coordinate environmental issues, and by participating in project related public participation meetings. Ms. Hickey graduated from the University of Toledo, with a bachelor of science degree in environmental science with an emphasis in biology, and holds a master of science degree in biology from John Carroll University.

Michelle Malcosky is a biologist who oversees ecological projects for Davey. She manages ecological and wetlands permitting projects, writes technical reports, and assists in wetlands investigations, ecological surveys, mitigation monitoring, endangered species surveys, and watershed studies. Ms. Malcosky conducts plant surveys with an emphasis on rare, threatened, and endangered species identification. In addition, Ms. Malcosky has extensive experience conducting habitat surveys and mist-netting studies for rare bats throughout Ohio. She currently holds a permit from the State of Ohio to conduct mist-netting surveys for the federally endangered Indiana bat (*Myotis sodalis*). Ms. Malcosky has been with Davey for four years and graduated from The University of Akron with a bachelor of science degree in biology with an emphasis on botany.

Deborah Sheeler M.A.: Ms. Sheeler has five years of experience and education specializing in GIS Analyses and Natural Hazards research. She is currently a GIS Analyst/Cartographer at Davey, where she focuses on designing, creating and producing maps through the use of advanced GIS software and automated mapping. In addition to geographic analyses and generating maps, she has experience in the field of aerial photography and remote sensing as a graduate teaching assistant and four years experience in monitoring, maintaining and technical support for pen-based computers. Ms. Sheeler has a Master of Arts degree in geography from Kent State University and a Bachelor of Science degree in geography from Central Missouri State University with a minor in Earth Science.