URBAN FORESTRY

Mississippi Urban and Community Forestry Management Manual

Second Edition | Stephen C. Grado, Stephen S. Strong, Marcus K. Measells

The Forest and Wildlife Research Center at Mississippi State University was established by the Mississippi Legislature with the passage of the Renewable Natural Resources Research Act of 1994. The mission of the Center is to conduct research and technical assistance programs relevant to the efficient management and utilization of the forest, wildlife, and fisheries of the state and region, and the protection and enhancement of the natural environment associated with these resources. FWRC scientists conduct this research in laboratories and forests administered by the University and cooperating agencies and industries throughout the country. Research results are made available to potential users through the University's educational program and through Center publications such as this, which are directed as appropriate to forest landowners and managers, manufacturers and users of forest products, leaders of government and industry, the scientific community and the general public. Dr. George M. Hoper is director of the Forest and Wildlife Research Center.

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by

Stephen C. Grado

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Introduction

Objective of the Manual

The objective of the Mississippi Urban and Community Forestry Management Manual is to address issues faced by, and provide management guidance to, community leaders in relation to the urban and community forest. The goal is to provide an effective tool for civic and community leaders, municipal officials, and concerned citizens to employ sound management guidelines to address their urban and community forestry needs.

Organization of the Manual

The Mississippi Urban and Community Forestry Management Manual is organized by chapters. Concentration areas for these chapters include, but are not limited to, costs and benefits; management strategies and ordinance development; wooded area conservation; stream protection; stormwater pollution prevention; water quality protection; trees on construction sites; and trees for streets, medians, parking lots, and shopping centers.

Justification for the Manual

The role of trees is taking on an increasing importance due to the intermixing of urban and wildland areas. Forested riparian zones and forested wetlands are often found in these interface areas and play vital roles in watershed function and health. Trees and forests should therefore be maintained and managed at levels adequate to provide the desired benefits to the community, satisfy applicable environmental regulations (such as stormwater regulations and non-point source regulations), and mitigate impacts. Some impacts that can be specifically mitigated include water temperature, peak flows, percolation, urban heat islands, sedimentation, pollutant transport in runoff, and nutrient loading. In fact, the addition of a single tree in an urban and community environment can increase the amount of rainfall interception by 7 to 22% and reduce sediment movement by 95%. Increase those percentages by acres of trees, and the rationale for establishing and maintaining urban and community forests is made readily apparent.

Users of this Manual

Ultimately, this manual will assist civic and community leaders, municipal officials, and concerned citizens in selecting solutions to address their urban and community forestry needs.

How to Use This Manual

The following provides a guide to the various chapters of the Manual.

Chapter 1 – Costs and Benefits of Using Trees in Urban and Community Environments.
This chapter provides an overview of the numerous costs and benefits involved with urban and community forest management.

Chapter 2 – Guidelines for Effective Urban and Community Forest Management.
This chapter provides guidelines for managing urban and community forests. Details and guidelines for community resource inventories development, natural resource based planning, community forestry management strategies, and urban and community forestry ordinances are provided.

Chapter 3 – Guidelines for Conserving Wooded Areas.
This chapter provides guidelines for conserving wooded areas at the landscape, subdivision, and lot levels.

Chapter 4 – Guidelines for Protecting Urban and Community Streams.
This chapter discusses methods for protecting urban and community streams. Topics include watershed-based zoning, sensitive area protection, buffer network establishment, and stream buffer performance criteria and ordinances.

Chapter 5 – Guidelines for Land Developers and Contractors.
This chapter provides guidelines for reducing disturbance, preserving vegetation, protecting sensitive areas, and controlling erosion on construction sites.

Chapter 6 – Guidelines for Controlling Stormwater with Urban and Community Trees.
This chapter provides guidelines and methods for controlling urban stormwater with urban and community trees. While man-made, structural methods of stormwater control are mentioned; stress is placed upon using native trees and vegetation whenever possible.

Chapter 7 - Guidelines for Addressing Natural Disturbances
This chapter provides guidelines for developing a readiness and response strategy that minimizes the initial damage and facilitates a more effective and sustainable recovery.

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Chapter 1: Costs and Benefits of Using Trees in Urban and Community Environments

Trees are a valuable asset and an integral part of a community's infrastructure. By performing essential biological functions, trees provide many substantial, measurable benefits for the community and environment. In contrast to other assets, trees have basic biological requirements for survival and growth, and, as a consequence, active tree management and protection is required to maintain tree health, function, safety, beauty, and value.

Since the costs and benefits of urban and community forests are quite extensive, it is up to each community to determine if urban and community forest-related projects achieve benefits that supersede the costs. If the benefits gained from urban and community trees are to be maximized, and the associated costs and risks are to be minimized, the community must have a good understanding of the benefits, costs, structure, and growth requirements of the trees themselves. Examples of variables that need to be considered include radiation loading, wind factors, stormwater runoff, property values, pavement degradation, tree removal and replacement costs, aesthetics, and noise issues.

Benefits of Urban and Community Trees

Trees provide a number of environmental, social, and economic benefits that may include, but are not limited to, air quality improvement, annual carbon dioxide reduction, increased annual net energy savings, stormwater runoff reduction (e.g., reduced flooding), flood water storage, erosion prevention, increased property values, noise reduction, aesthetics, and wildlife benefits. Quite often, these benefits are tangible and measurable in terms of dollar value. Some of the more important benefits are included below:

Improved Air Quality

Urban trees help to improve air quality in four main ways:

- ≈ oxygen release through photosynthesis,
- ≈ gaseous pollutant absorption (e.g., ozone, nitrogen oxide, sulfur dioxide) through leaf surfaces,
- ≈ particulate matter interception (e.g., dust, ash, pollen, smoke), and
- ≈ water transpiration and surface shading, which lowers local air temperatures and reduces ozone levels.

During photosynthesis, tree leaves absorb carbon dioxide and produce the oxygen we require to breathe. In fact, a single large, healthy tree can produce enough oxygen daily for 18 people.

Additionally, tree leaves absorb other pollutants like carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter from the air. In fact, tree canopy cover of as little as 24% has been shown to remove up to 89,000 tons of pollutants annually, with a value of $419 million. Other studies suggest that deciduous and evergreen trees remove up to 9% and 13% of particulates in the air, respectively, and the estimated annual value of pollutant uptake by a typical medium-sized tree is between $12 and $20. Figure 1-1 illustrates how tree leaves absorb pollutants and intercept rainfall.

Trees also provide direct shading to buildings, parking lots, and road surfaces. Shading not only reduces temperatures but also indirectly reduces ozone and volatile organic compounds (VOCs) released from automobiles and biogenic volatile organic compounds (BVOCs) released from certain tree species.

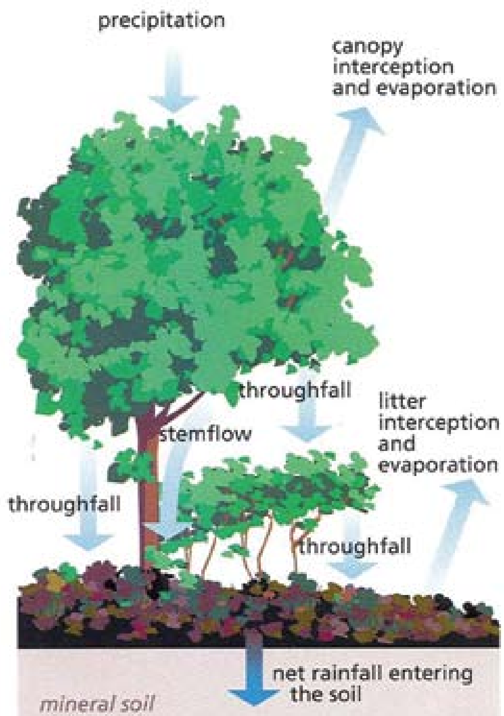

Figure 1-1. Illustration of a tree's hydrologic cycle. Source: Cappiella et al., 2005.

Reduced Atmospheric Carbon Dioxide

Urban forests can reduce carbon dioxide in two ways:

- ≈ direct CO_2 sequestration in woody and foliar biomass during growth, and
- ≈ reduced demand for heating and air conditioning, resulting in reduced emissions from electric power production.

On average, a mature tree can absorb and store 13 pounds of carbon per year in its roots, trunk, and limbs, and an urban or community forest can sequester or store as much as 2.6 tons of carbon per acre per year. The collective storage capacity of urban and community trees across the United States is 6.5 million tons per year, resulting in a savings of $22 billion in control costs. For each pound of carbon removed, $1.70 is saved, which equates to an annual savings of $22 from carbon storage by each tree.

For each pound of wood grown, a tree absorbs 1.47 pounds of carbon dioxide and emits 1.07 pounds of oxygen. It is therefore possible that an acre of trees might grow 4,000 pounds of wood in a year, absorbing 5,880 pounds of carbon dioxide and emitting 4,280 pounds of oxygen. Alternatively, for every pound of decayed or burned wood, 1.07 pounds of oxygen are absorbed, and 1.47 pounds of carbon dioxide are emitted.

Increased Energy Conservation

Urban trees conserve energy in three principal ways:

- ≈ shading – reduces amount of radiant energy absorbed by building surfaces,
- ≈ transpiration – converts moisture to water vapor and cools using solar energy that would otherwise result in air heating, and
- ≈ wind speed reduction – reduces infiltration of outside air into interior spaces and heat loss where thermal conductivity is high.

Tree crowns create a shade canopy for homes, offices, streets, parking lots, and pavement. This canopy reduces the amount of sunlight reaching our streets, lawns, and parking areas, and results in lower summer temperatures. In fact, air temperatures in trees and greenspace within individual building sites may be as much as 5°F lower than outside the greenspace. Trees properly placed for optimal shading of buildings (south and west sides) and air conditioners, can provide a 17 to 75% decrease in summer cooling costs. While the presence of a thick evergreen canopy can increase winter heating costs in some areas by reducing sunlight infiltration, properly placed trees in Mississippi generally decrease winter heating costs and serve to buffer a home against cold winter winds (north and west sides).

In a single growing season, the 200,000 leaves typically contained on a healthy 100-foot tree can uptake 11,000 gallons of water from the soil and transpire that water into the air. The cooling effect of transpiration is equivalent to air conditioning for 12 rooms.

Windbreaks composed of urban and community trees reduce wind speed and air infiltration by up to 50%, which potentially leads to annual heating savings of 25% or more. Additionally, heat transfer through conductive materials is decreased as a result of reduced wind speed.

Reduced Stormwater Runoff

Urbanization and land development alters and reduces natural vegetation, reduces natural infiltration properties of the watershed, significantly increases runoff amounts, and decreases water quality. Development-affected waterways experience a change in form and function that results in degraded systems no longer capable of providing good drainage, healthy habitat, or natural pollutant processing. In fact, conversion of forest to impervious cover can result in an estimated 29% increase in runoff during a peak storm event and ultimately result in lost habitat, unstable streams, degraded water quality, and reduced biological diversity.

Figure 1-2 illustrates how impervious surfaces alter hydrology, effectively creating a barrier to rainfall percolation into the soil, increasing surface runoff, and decreasing groundwater infiltration. As the percentage of impervious cover increases, there is a corresponding increase in runoff and decrease in evapotranspiration and infiltration, which leads to water pollution, habitat degradation, property damage, and the need for artificial stormwater control devices.

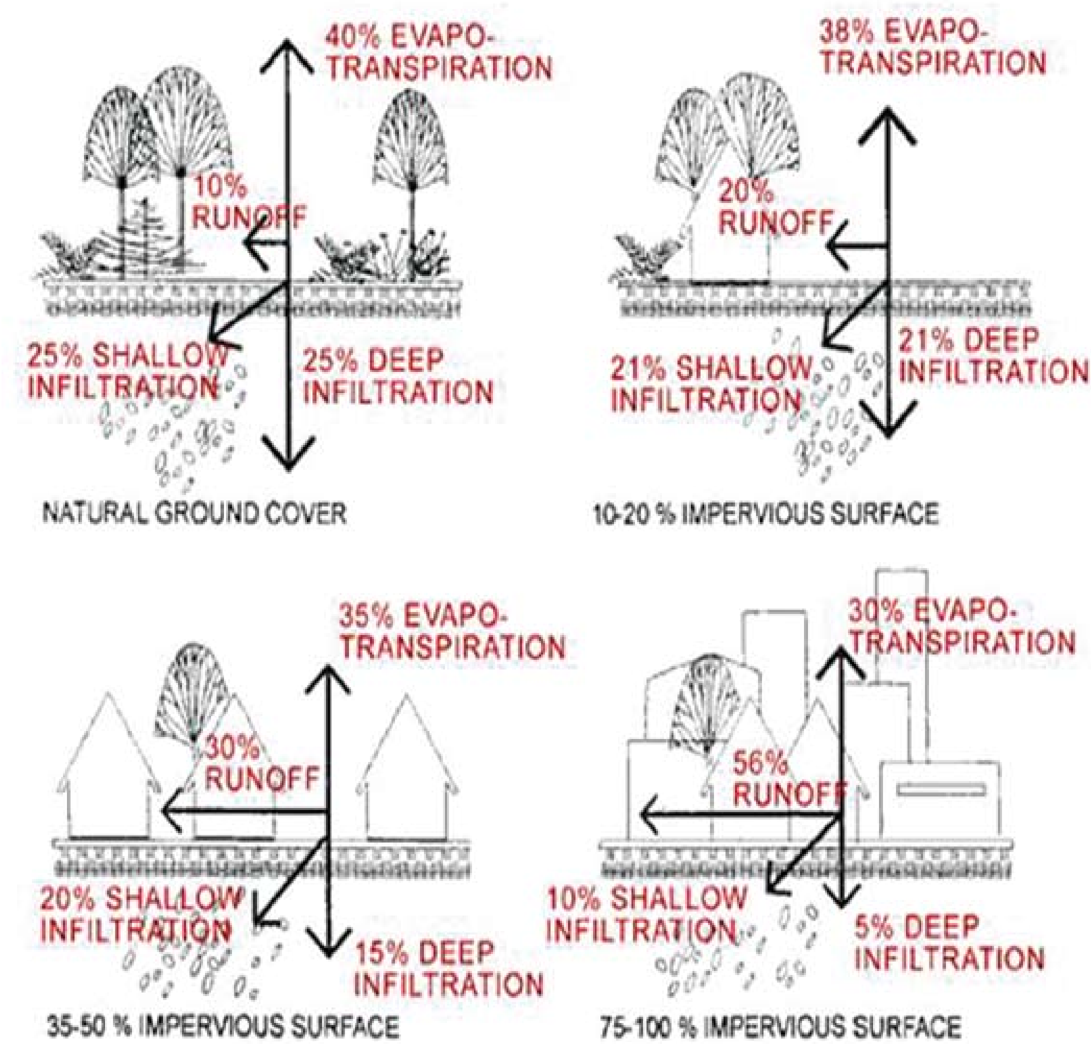

Figure 1-2. Water cycle changes associated with urbanization. Source: USEPA 1993.

Healthy urban forests can help to counteract urbanization effects by reducing the amount of stormwater runoff and pollutant loading in three primary ways:

- ≈ leaves and branch surfaces intercept and store rainfall, reducing runoff volumes and delaying onset of **peak flows**,
- ≈ root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and reduce **overland flow**, and
- ≈ canopies reduce soil erosion by diminishing the impact of raindrops on barren surfaces.

Urban trees are structurally important to communities because their many leaves, branches, stems, and roots aid in rainfall interception, storage, and release to the soil. When trees are present, water flow is spread over a greater amount of time, and the impact on stormwater facilities is smaller. By incorporating trees into a city's infrastructure, cities can afford to build smaller, less expensive stormwater management systems. Because trees intercept 7 to 22% of precipitation, the value of trees can be measured by the reduction in construction and material costs for stormwater control structures and systems. One study has shown that, for every gallon of water intercepted by a tree during a twelve-hour storm, 2 cents in water control costs are saved. This equates to a 17% reduction of 11.3 million gallons, and a savings of $226,000 for a medium-sized city! In an Ohio study, an existing tree canopy with just 22% coverage reduced potential runoff by 7%, and an increase in canopy coverage to 29% reduced runoff by nearly 12%. By reducing runoff, trees function as natural retention-detention structures because increased interception and subsequent water storage greatly reduces the chances of flood damage to property and crops, and eliminates the need for costly stormwater treatment and control structures.

Furthermore, the amount and velocity of overland flow and **non-point source** (NPS) pollution that occurs during and after heavy rains is greatly decreased when trees are present. Simulations of urban forest effects on stormwater report annual runoff reductions of 2 to 7%. Reductions in flow amounts and velocities equate to less erosion and better infiltration and storage, ultimately leading to less damage to the watershed and the surrounding environment. Because of its water storage abilities, retaining, maintaining, and restoring forest land, particularly in riparian and bottomland areas, should be a priority for Mississippi communities. Allowing these areas to undergo development can create a need for expensive drainage projects to alleviate flooding. Simple planning, a little foresight, and help from nature can save communities both time and money in the long-run.

Improved Water Quality

Trees in urban riparian or streamside forests control fluctuations in water temperatures and act as natural filters by absorbing pollutants and other toxins before they can enter underground

water systems. This, in effect, reduces the amount of polluted water that runs off urban and community streets, into sewers, and eventually into the groundwater, and also prevents thermal pollution of water resources. Additionally, trees in urban riparian forests maintain light levels that sustain beneficial algae as well as other stream flora and fauna.

Urban and community forests can also help improve water quality through treatment and disposal of wastewater on irrigated nurseries or plantations. Wastewater reuse can help to recharge aquifers, reduce stormwater treatment loads, and create income when used for nurseries or wood products. Furthermore, urban wastewater recycled through greenspaces provides an economical means of treatment and disposal and provides other environmental benefits.

Reduced Soil Erosion

Streams lacking urban riparian or streamside forest channels are prone to channel widening and bank erosion, and any fundamental change in the dimension, pattern, and profile of a channel results in habitat loss. Numerous studies attest to the ability of urban riparian forests to remove, hold, or transform nutrients from fertilizers, sediments, and other pollutants. In fact, urban and community trees can reduce sediment movement off a site by 95% even before water reaches the riparian forest, effectively keeping our water bodies cleaner and healthier. The amount of soil saved in a medium-sized city annually can be as much as 10,886 tons!

Wildlife Food and Habitat

Although less biologically diverse than rural woodlands, urban and community forests are home to many wildlife species and provide much-needed food and shelter in the urban environment. Flowers, fruits, leaves, buds, and woody parts of urban and community trees are used by many birds, mammals, insects, and other wildlife species. Bacteria and fungi contained in tree parts cause decay and increase soil fertility and structure. Elsewhere, along streams, urban and community trees provide shade, reduce water temperatures, contribute to the overall health of aquatic ecosystems by providing habitat, shelter, and food for aquatic organisms like turtles, otters, beavers, and fish, and often connect a city or community to its surrounding bioregion.

Increased Aesthetic Appeal

Trees placed in urban and community areas create an aesthetically pleasing and comfortable place in which to live, work, and shop. In fact, beautification is one of the most frequently cited reasons for planting trees, and research has shown that street trees are the single strongest positive influence on scenic quality. Trees also attract more residents and visitors to a community, increasing the community's tax and economic base. Surveys of consumers found that the presence of trees in commercial areas increases preference ratings, results in more frequent and extended shopping, and evokes higher willingness to pay for goods and services.

Adding or retaining trees in recreational areas creates a natural setting for activities such as walking, jogging, bicycling, golfing, and bird watching. Studies have found that urban and community park visitors preferred wooded to non-wooded parks. Residents of public housing complexes used outdoor spaces with trees significantly more often than spaces without trees. It has been further suggested that urban and community trees can strengthen social interactions, thereby reducing domestic violence, fostering safer and more sociable neighborhoods, and creating a sense of pride among residents. Others have established a connection between the presence of urban trees and crime reduction.

The presence of trees in cities and communities provides social and psychological benefits by answering the human need for contact with nature, and creating a general sense of human well being through interaction with greenspace. Studies have shown that trees and views of nature provide pleasure and restorative experiences, ease mental fatigue and aid in concentration, result in reduced sickness and greater job satisfaction, reduce stress response, induce better sleep and reduced medication in hospital patients, and reduce exposure to ultraviolet light.

Urban and community trees can also result in increased property values. Trees can provide an owner of a single home with a 4 to 27% increase in property value, and a single tree can add as much as 9% to the total value of a residential property. Scientists have found that each large front-yard tree increased actual sale prices by 1% each. One study has shown that each hardwood tree on a site adds $333 to the property value and each pine adds $257.

Trees soften the glare and hard lines of developed city streets, screen buildings, reduce noise pollution, act as sound barriers or screens, and create natural noise amid city sounds. In cities, noise levels can reach unhealthy levels, with trucks, trains, and airplanes sometimes exceeding 100 decibels, which is two times the level at which noise becomes unhealthy. Thick vegetation strips, in conjunction with solid barriers and landforms, can reduce highway noise by 6 to 15 decibels and absorb high frequencies that are most distressing to humans.

Forests, wetlands, meadows, and other natural areas provide essential ecological services such as providing floodwater storage, filtering runoff, moderating outside temperatures, storing carbon emissions, controlling erosion, providing visual and auditory screening, and providing natural aesthetics. When these areas are degraded or destroyed, communities are then forced to spend large sums of money to construct technologies that mimic natural functions.

Megan Bean, MSU

Real-Life Examples of Benefits to Mississippi Communities

Many Mississippi cities and communities are presently involved in programs that directly or indirectly influence and result in the numerous urban and community benefits previously discussed. These programs are administered by diverse sources (i.e., local and state governments and agencies, public and private organizations), but most have, as their mission, providing communities with information and services to help them accomplish community improvement goals.

One very successful example of such a program is the Mississippi Main Street Association (MMSA), a private, non-profit organization contracted with the Mississippi Development Authority in 1989 to administer the Main Street Program. MMSA provides technical assistance and directs the revitalization efforts of downtowns and surrounding neighborhoods throughout Mississippi.

Since its inception, MMSA has, through strong partnerships and well-coordinated efforts, successfully assisted with the creation of over 1,000 new businesses and thousands of new jobs in numerous communities throughout the state. For example, in Columbus, MS, since 1985, 143 new businesses have been created; 8 businesses have expanded; 47 buildings have been improved; and 669 new jobs have been created (Appendix A). MMSA accomplishments for 40 other Mississippi communities are provided in Appendix A.

In just 15 years, MMSA has helped communities throughout our state instill new life into downtowns and business districts that were once forlorn and neglected, creating an in-flux of economic development and profit and instilling wide-spread community pride. In Mississippi, as well as many other U.S. states, downtowns are once again becoming the heart, center, and core of the community.

As a direct result of MMSA revitalization efforts, participating Mississippi communities are reaping many benefits, not the least of which is "greener" downtowns. The addition of trees or "greening" of downtown settings creates an attractive retail and business setting and welcomes both shoppers and visitors. In fact, a 2003 study conducted in Athens, GA demonstrated that the presence of trees increases shopper and visitor amenity and comfort, creates a more positive interaction with merchants, advertises the high quality of products available in the district, and demonstrates proper maintenance and upkeep. Benefits from trees in downtown settings perceived by survey respondents in the study included:

≈ environmental benefits (e.g., downtown wildlife habitat, reduced heat radiation, improved air purification, increased precipitation shelter, and improved noise and auto pollution buffering);

≈ amenity values (e.g., improved aesthetic pleasure, increased shade, softened store fronts, added color to store-fronts); and

≈ downtown character (e.g., inviting and pleasant atmosphere, creation of pedestrian pockets, reduced starkness of landscape, area uniqueness and distinction).

Additionally, revitalizing downtown or central business districts through the use of urban trees can help to alleviate intense retail competition from discount retailers, regional malls, and online shopping. Revitalizing these areas creates places with distinct character and appeal that is not possible in discount or "mega" retail centers and far outweighs the seeming convenience of visiting those centers. In fact, surveyed consumers have expressed willingness to subject themselves to increased distance and time of travel, increased frequency and duration of visits, and increased prices paid for parking in retail places that have trees. These findings suggest that the time, money, and effort needed to create and steward a downtown urban forest is more than offset by the compensatory economic and aesthetic returns to the city and community as a whole.

Costs of Urban and Community Trees

In addition to providing many benefits and being a valuable community asset, urban and community trees have costs associated with their conservation, establishment, and maintenance. These costs usually revolve around tree purchase and planting, annual trimming, tree and stump removal and disposal, pest and disease control, irrigation, infrastructure damage, litter and storm clean-up, litigation, and program administration. More specifically, neglected, unprotected, abused, or poorly maintained trees result in poor health, an increased risk for failure, and additional liability for the tree owner. A Tree Management Cost Worksheet is provided in Appendix B to assist in planning for costs associated with tree conservation and management. Additionally, a list of long-term cost saving strategies for tree conservation and management is included in Appendix B. While there are many costs associated with trees, in most cases benefits far outweigh costs. The ratio of benefits to costs can be much improved with the implementation of the guidelines in Chapter 2. Some of the direct and indirect costs involved with urban and community trees are described below.

Planning and Design Costs

Planning and designing an urban and community tree plan, evaluation, or survey project requires a great amount of time and money, but careful planning and quality design can result in a more successful and valuable project achieving high income levels. Some important elements of urban and community tree project planning and design include:

- ≈ quality planting stock – expensive, but purchasing good quality trees reduces future replacement and maintenance costs,
- ≈ tree maintenance – regular pruning insures tree health, safety, and longevity,
- ≈ tree monitoring and protection – reduces chances of damage from construction activities, utility line installation or repair, and pest problems, and
- ≈ tree removal – necessary when trees decline beyond the point of improvement or die, can be expensive for large trees.

Tree Hazards

Urban and community trees must not be allowed to grow into the clear zones designated for utility lines, pedestrian walkways, buildings, streets, and vehicle equipment travel lanes. Excess growth into these zones reduces clearance and sight distance and causes increased costs to maintain public safety. Additionally, portions of or whole trees that, either in the present or in the future, tower over property can cause utility service outages, vehicle, home, fence, or pavement damage, and lead to personal injury. For example, tree roots that surface above ground can be a tripping hazard for humans and can cause damage to lawn mower blades. Additionally, unpruned branches can cause severe personal injuries or even death.

Infrastructure Conflicts

In many cities across the U.S., communities are spending millions of dollars annually to manage and resolve conflicts between trees and sidewalks, sewers, power lines, and other elements of urban infrastructure. In previous studies, repair costs for sidewalk, curb and gutter repair, tree removal and replacement, prevention methods, and legal/liability costs range from $0.75 to $2.36 per capita and up to $6.98 per resident. When additional expenditures for damaged sewer lines, building foundations, parking lots, and other hardscape elements are included, total costs can soar to $100 million per year in larger cities.

Unfortunately, in some areas, the high costs of infrastructure maintenance and dwindling fiscal budgets have forced municipalities to shift costs of sidewalk and other repairs to residents. This attempt to control costs has had an harmful effect on urban forests as a whole because cities have been forced to downsize urban forests by planting smaller stature trees, remove greater numbers of trees due to sidewalk damage, and remove more trees than are being planted. Most of these problems could easily be avoided by simply matching growth characteristics to conditions at the planting site.

Under favorable soil moisture conditions, tree roots will penetrate underground water and sewer lines through small cracks or pipe joints, proliferate, and cause problems. Repair costs for damaged water and sewer lines are expensive, typically ranging from $100 to $1,000 per pipe.

Throughout the year, urban and community trees drop leaves, flowers, fruit, and branches that collect as debris on city streets and can clog sewers, dry wells, and other elements of flood and stormwater control systems. Large expenditures from additional labor needed to remove debris, property damage from localized flooding, and clean-up costs after windstorms can be avoided by employing street sweepers on a regular basis.

Conflicts between trees and power lines often result in increased electric rates and decreased benefits from over-pruning of poorly-suited trees. In areas with thousands of trees, pruning costs can be as high as $50 per tree, and this cost is, more often than not, passed on to the consumer. Most of the above problems can be minimized or avoided by simply matching tree species to planting sites.

Benefit/Cost Analysis for Urban and Community Trees in Hattiesburg, MS

The city of Hattiesburg, Mississippi recently served as the basis for the model used to develop an affordable approach to assess street tree populations in small communities. This approach provided four types of information:

≈ tree structure (species composition, diversity, age distribution, condition),
≈ tree care needs (sustainability, canopy cover, pruning, young tree care),
≈ tree function (magnitude of environmental and aesthetic benefits), and
≈ tree value (dollar value of net benefits realized).

Results of the project provided Hattiesburg and other small- to medium-sized southern communities a baseline for assessing their street trees and developing cost-effective tree planting and care programs. Project results also provided Hattiesburg with a benefit/cost ratio (BCR), which will help city managers justify costs associated with their urban forestry activities and programs.

Total annual benefits from Hattiesburg's street trees were calculated from dollar values for net energy savings (i.e., annual natural gas savings + annual electricity savings); net air quality improvement (i.e., PM_{10} interception + NO_2 absorption + O_2 absorption); carbon dioxide reductions (i.e., CO_2 sequestered less releases + CO_2 avoided from reduced energy use); stormwater runoff reductions (i.e., effective H_2O interception); and aesthetics (i.e., increased property values). Total annual costs for Hattiesburg's street trees were calculated from dollar values for planting; pruning; tree and stump removal and disposal; pest and disease control; establishment/irrigation; repair/mitigation of infrastructure; litter/storm clean up; litigation and settlements related to tree-related claims; program administration; and inspection/answering service requests.

During the 2003-2004 fiscal years, publicly maintained street trees produced nearly $1.25 million in tangible benefits for the residents of Hattiesburg. This amounted to an average of $111.24 per publicly maintained tree or approximately $22.73 for every resident. Total annual benefits divided by total annual costs yielded a BCR of 4.1:1. Therefore, the city's street trees returned $4.10 to the community for every $1 spent on their management!

Hattiesburg, Mississippi's BCR (4.1:1) compared favorably to that of Davis, California's (3.78:1). Forty percent of the annual benefits were attributed to environmental values. Of this total, energy savings and improved air quality—benefits that are locally realized—constituted the majority of this value. Though of lesser proportion functionally, reductions in CO_2 and stormwater runoff were also significant.

While species varied in their ability to produce benefits, common characteristics of trees within tree type classes aided in identifying the most beneficial street trees. Comparatively, large trees produced the most benefits. However, the average large deciduous tree produced nearly 30% more than a large conifer and almost 50% more than a large broadleaf evergreen. Comparisons within tree types were more striking. Even the most immature of the large-stature deciduous trees produced more annual benefits than mature, small-stature trees of the same type. Medium deciduous trees out-performed large broadleaf evergreens and rival the benefits produced by the average large conifer.

Chapter 2: Guidelines for Effective Urban and Community Forest Management

Conducting a Community Resource Inventory

Every community possesses an array of resources and qualities that give it unique character and sense of pride. These resources are vital to the well-being and long-term success of the community and must be protected. Communities desiring to embark on a resource-based planning process, with an ultimate goal of sustainable development, are well-advised to conduct an inventory of the community's resources.

One approach, called Community Resource Inventory (CRI) consists of three separate resource inventories: natural, social, and economic. These inventories, taken separately or as a whole, provide the information needed for a community to make informed and rational decisions about land use. Conducting a CRI requires a 6-step process:

1. Assemble a small working group of knowledgeable citizens. This group should acknowledge the responsibility of other civic boards and commissions for creation and maintenance of the inventories.
2. Determine the study area of the inventory. The inventory process is fundamentally the same, no matter the scale (e.g., site, town, watershed, or region.) The best scale for a community to use is that which best suits its needs.
3. Review existing documents that were previously completed by the community. These documents may include: conservation and development plans, resource inventories, and special studies or plans. Work of adjacent jurisdictions and/or the help of a regional planning agency may also be helpful.
4. Assemble maps and information from local and state sources. Maps are available from a variety of different sources. When assembling the maps, caution should be taken not to get overwhelmed by details. Remember to gather only that information which will help the community make better land use decisions.
5. Write a draft report. The report should include both a map and sources, along with a narrative that describes that map and how it may or may not be used. A list of maps and data sets used for the CRI is included in Appendix B.
6. Publicize and solicit information to both the town's boards and commissions and to citizens. Use all available resources to publicize the importance

of this information to the community. Solicit input from citizens and incorporate constructive and improved information into the inventory.

Information from the CRI can be incorporated into nearly all planning decisions that affect the community, from open space to economic development. If the CRI information is to be effective, commissions assigned the responsibility for the inventory must keep it up-to-date. The inventory should be revisited to ensure that the most current information available is provided to the community's decision makers.

Natural Resource-Based Planning

When community planning and decision-making revolve around natural resources, a thorough and correct natural resource inventory is essential. The inventory should first be conducted at the landscape-level by an interdisciplinary team comprised of individuals from natural resource professions, civic, federal, state, and local governments, concerned community organizations, and nonprofit organizations. The inventory should include a woodland survey and resource assessment, and should produce a Comprehensive Landscape Resource Map, containing all pertinent survey and assessment information (Figure 2-1).

Following the inventory, communities can begin developing an open space plan that is sensitive to the area's unique sense of place and its natural resources. Open space can best be categorized by the functions that it achieves.

Figure 2-1. A resource map such as this example of the city of Cottage Grove, Minnesota shows the location of important features of the landscape including tree stands, water bodies, historical sites, and existing land use. Source: Minnesota DNR 2000.

Six functional types of open space include:

- ≈ natural resource protection areas, (e.g., animal and vegetative habitat, streambelt corridors, and rock ridges;
- ≈ outdoor recreation;
  - active, (e.g., parks, playgrounds, beaches, and trails); and
  - passive, (e.g., plazas, sitting areas, arboretums);
- ≈ resource management, (e.g., forests, fisheries, and farmland);
- ≈ protection of public health and safety (e.g., floodplains, wetlands, unbuildable areas, or areas with limitations for development);

≈ areas that shape community character or design (e.g., buffer strips, front, back, and side yards, urban plazas, greenways, open space dedications); and

≈ historic or archeological sites (e.g., battlegrounds, historic structures and grounds, historic districts, town greens).

No matter what the intended function for open space, it is important that a community possess a unifying game plan to address new development with a directive, rather than reactive approach. The desires and needs of the community regarding any new development should be communicated clearly and frequently so that irreversible, harmful mistakes are not made.

After the open space plan has been developed, a more thorough plan of conservation and development can be created. This plan consists of designating areas of no new development, limited development, and suitable future development. Examples of areas not to be developed include existing developments, committed open spaces, and regulated wetland areas. These areas can be permanently protected through conservation easements. Areas with limited development include those with little net buildable area or those with large lots. These areas can be designed with conservation in mind, making shorter, narrower roads and creating new open space. Areas suitable for future development are those areas considered "growth areas" by communities (e.g., shopping centers, new subdivisions). Whenever possible, areas of limited or new development should be viewed in a regional perspective and possibly linked to form greenways. Additionally, any new developments or alterations to existing developments should incorporate native natural vegetation and trees.

Developing a Community Forest Management Strategy

Tree ordinances provide the legal framework for successful urban and community forest management by enabling and authorizing management activities. However, methods for managing urban forest ecosystems are continually evolving, and the input of trained professionals to the management process is critical. Therefore, ordinances should facilitate rather than prescribe management, and communities need to develop or review their overall urban forest management strategy before considering a new or revised urban and community forestry ordinance.

In developing or reviewing an overall management strategy, a community should ask itself four questions and follow seven corresponding steps (all information taken directly from ISA 2001). Working through the steps is ultimately driven by specific goals and resources of the individual community. By following the process outlined below, a small community with very modest forest management goals can develop a simple ordinance that addresses its limited goals. Conversely, communities seeking to develop a comprehensive tree management program or expand their existing programs can do so following the same process. In either case, the ordinances developed will be uniquely suited to community needs.

Question 1. What do you have?

Step A. Assess the tree resource.

An assessment of tree resources provides the basic information necessary for making management decisions and provides a baseline against which change can be measured. Ideally, this assessment should include all tree resources within the planning area of the municipality.

Tree resource assessments are based on various inventory methods, most of which require some type of survey. Complete tree inventories of all public trees are relatively common, and play a central role in many tree management programs. However, complete tree inventories can be very costly and may exceed the budget and needs of smaller communities. In these cases, an estimate of tree population density taken from a sample inventory may be more suitable. Appendix B outlines a sample tree inventory process.

Useful information obtained from the assessment includes:

≈ total number of trees classified by species, condition, age, size, and location,
≈ problem situations, such as sidewalk damage, disease and pest problems, or hazardous trees, preferably linked to the basic tree data above, and
≈ amount of canopy cover by location.

The complexity of inventories can vary depending on community size and nature of the data collected. City staff, consultants, or volunteers can be trained to make inventories, as long as steps are taken to make sure the data is valid and reliable. For example, in one city, a tree inventory was completed as an Eagle Scout project.

Step B. Review tree management practices.

Understanding the status of the urban or community forest requires knowing how it has been previously managed. Some information that should be collected on past and current management methods and actions includes:

- ≈ municipal tree care practices, including planting, maintenance, and removal,
- ≈ existing ordinances, and level of enforcement practiced (i.e., numbers of violations, permits and citations issued, penalties and fines collected),
- ≈ planning regulations and guidelines pertaining to trees, and numbers of tree-related permits granted, modified, or denied, and
- ≈ activities of municipal departments and public utilities that impact trees.

The purpose of reviewing past and current tree management practices is to identify all activities affecting trees in the community, especially those falling under municipal control. For instance, seemingly unrelated ordinances and planning regulations may directly or indirectly impact forest resources and, therefore, must be taken into account.

Question 2. What do you want (i.e., goal-setting)?

Step C. Identify Needs.

Once information on the status of tree resources and tree management is in hand, a community can assess its urban forestry needs. Urban and community forestry needs can be grouped into three broad categories, with some needs falling into more than one category.

Biological needs (i.e., related to the tree resource itself):

- ≈ increase species and age diversity to provide long-term forest stability,
- ≈ provide sufficient tree planting to keep pace with urban growth and offset tree removal,
- ≈ increase proportion of large-statured trees in the forest for greater canopy effects, and
- ≈ guarantee proper compatibility between trees and planting sites to reduce sidewalk damage and conflicts with overhead utilities that lead to premature tree removal.

Management needs (i.e., needs of those involved with the short- and long-term care and maintenance of the urban forest):

- ≈ develop adequate long-term planning to guarantee the sustainability of the urban forest,
- ≈ optimize the use of limited financial and personnel resources,
- ≈ increase training and education for tree program employees to ensure high quality tree care, and
- ≈ coordinate tree-related activities of municipal departments.

Community needs (i.e., those that relate to how the public perceives and interacts with the urban forest and the local urban forest management program):

- ≈ increase public awareness of values

and benefits associated with trees,
- promote better private tree care through better public understanding of the biological needs of trees,
- foster community support for the urban forest management program, and
- promote conservation of the urban forest by focusing public attention on all tree age classes, not just large heritage trees.

Although the needs listed above are common in many communities, specific needs of each community will vary, and may include others not noted here.

Step D. Establish Goals.
With information on resources and needs collected, goals to address local urban forestry needs can be set and a management strategy formed. To establish realistic goals, it is important to consider limitations posed by the level of community support, economic realities, and environmental constraints. Limitations on resources may make immediate addressing of all identified needs impractical and, in this case, it will be necessary to prioritize goals.

Community involvement and support are critical in the establishment of goals since most urban and community forestry ordinances rely heavily upon voluntary compliance by the public, and compliance will only occur if the public supports the goals set. Involving the public in the goal-setting process allows them to reflect on the values of their community as well as educate themselves on how urban forest management affects their community.

Since goals are tangible ends that the management strategy seeks to achieve, it is important to set goals which are quantifiable, so that progress toward achieving these goals can be monitored. Typical tree program goals, as well as corresponding ordinance provisions for each goal, consistent with good urban forest management are discussed in detail in Appendix B.

Question 3. How do you get what you want?

Step E. Select tools and formulate the management strategy.
This step develops a management strategy addressing specific goals. It is important to remember there are many approaches that can be used to address each goal, and the pros and cons of each approach should be considered. Feasibility, practicality, legality, and economics should be considered in selecting appropriate management tools. Some typical tools include:
- public education programs,
- assistance and incentive programs,
- voluntary planting programs,
- mitigation guidelines,
- planning regulations and guidelines, including the general plan and specific plans, and

≈ ordinances.

Community involvement and support continues to be important in this phase of the process; if management approaches and tools are unacceptable to the community, they are unlikely to succeed. Your assessment of current and past management practices should provide ideas about the effectiveness of various methods used in your community, and public input and comment should be sought for any new approaches being contemplated or developed.

The role of an ordinance becomes apparent at this stage, when it may become necessary to establish new positions, require development and implementation of a community forest master plan, mandate a program of public education, or outlaw destructive practices. Any provisions placed in ordinances should be directly related to the goals your community has established for its community forest, and all ordinances should include all of the essential components previously listed.

Step F. Implement the management strategy.

No matter how ideal a plan may appear on paper, it cannot achieve its goals until it is implemented. Implementation of the management strategy requires several steps, which may differ between communities, and include:

≈ passing an ordinance,

≈ budgeting necessary funds,

≈ hiring a municipal forester or arborist,

≈ appointing a citizen tree advisory board,

≈ formulating a master tree management plan, and

≈ developing public education programs.

The above steps need not require funding if a volunteer tree board can be formed and ordinances are in place. The city of Pass Christian, MS implemented their management strategy without funding and saved many trees.

It is often useful to map out an implementation schedule to accomplish the steps involved in your community's management strategy. The schedule should show the steps involved and the time frame within which they should be completed. Additionally, progress checks in the form of required progress reports to the city council or county board of supervisors should be built into the schedule to make certain that delays or problems are detected and addressed. Maintaining a high profile for the management program during implementation will help foster public interest and maintain the commitment of local government.

Question 4. Are you getting what you want?

Step G. Evaluate and revise.

Monitoring of your implemented management strategy is essential to make certain that progress is being made and standards are being met. Evaluation provides feedback on the effectiveness of the strategy, provides opportunities to reassess the needs and goals of the community, and allows readjustments and changes to goals before a crisis develops. Specific methods to monitor ordinance effectiveness are included in Appendix B.

Hattiesburg's Community Forest Management Strategy

Question 1. What do you have?

Step A. Assess the tree resource.

In 2004, a sample tree inventory was undertaken to assess Hattiesburg's tree resources. The aim of the sample inventory was to provide a reliable estimation of street tree species, diversity, population, and other variables (i.e., pruning needs, canopy cover, tree condition).

To facilitate the street tree inventory, the city wards of Hattiesburg were delineated and divided into regions of similar land-use, demographic character, and street layout. Zone segments were numbered, and the total linear street length found in each zone's segments was measured and recorded. Random samples were then chosen within each zone to serve as sampling units. Within the sampling units, all trees falling within 15 ft. of street edge were inventoried according to established protocols. Data collected for each tree included species, land use, location, size, pruning requirements, condition, conflicts, and shading.

Step B. Review tree management practices.

Data collected during the sample inventory facilitated assessment of structural components and management practices (i.e., canopy coverage, conditions, distribution, pruning needs) as well as other conflicts associated with public safety for Hattiesburg's street trees. This assessment was categorized by ward and zone type to show where management is needed most to improve street tree health and sustainability, and to show how investing in a management program has provided benefits through maintenance of street trees.

Question 2. What do you want (i.e., goal-setting)?

Step C. Identify Needs.

Calculations of overall canopy cover, condition of street trees, street tree distribution by land use, and pruning and maintenance needs aided the city in an assessment of overall management needs.

Canopy cover is the driving force behind an urban forest's ability to produce benefits in the community. As canopy cover increases, so also do the benefits afforded by increased leaf area (e.g., greater rainfall interception, shade, cooling, CO_2 reduction, pollutant uptake, aesthetics). Residents pay the city to manage street trees for the benefit of the community, and to realize the maximum return on this investment, a city should strive to maintain present canopy cover in a way that promotes annual increases. Hattiesburg's citywide canopy coverage was 31% over all zones sampled.

Determining suitability of street trees to a location is a method which can be assessed by a tree's condition. Conditions of Hattiesburg's street trees varied with each zone. Citywide street tree conditions averaged 62% good, 25% fair, and 13% dead or dying. Over all zones, good trees ranged from 41 to 83%. Fair trees ranged from 12 to 34%, while dead and dying trees ranged from 2 to 25%.

Street tree distribution by land-use followed the basic development of Hattiesburg, having the vast majority of the city's land area in single home residential neighborhoods. Many of these trees are volunteers that were left or seeded naturally from the forest within which the city was developed.

Unfortunately, budget constraints of municipal tree programs often dictate the length of pruning cycles and maintenance regimes rather than the needs of the urban forest and its constituent components. In fact, many cities do not have a programmed pruning plan, but maintain trees under "request" and "crisis" mode, finding them further and further behind every year. Programmed pruning, under a reasonable time line, can improve public safety by eliminating conflicts, reducing costs by improving program efficiency, and increasing benefits by improving tree health and condition. Any short-term dollar savings realized by cities deferring pruning only do so at the expense of lost tree value. All zones in Hattiesburg showed that around 20% of the street tree population required pruning.

Step D. Establish Goals.

Hattiesburg outlined its wants and desires for its urban forest management program on June 4, 1991, when the City Council passed its first true tree ordinance creating the city's first tree board. This five member board provided oversight and guidance in establishing a community forestry program and influenced decision-makers to pass the second tree-related ordinance in 1993. This ordinance provided for a broader spectrum of professional expertise on the board (i.e., an arborist, a landscape architect, a horticulturist) and more community involvement by expanding the board to seven members. This board worked to obtain grants (i.e., America the Beautiful 1991, $10,000; Small Business Administration 1991, $22,500; Georgia Pacific Corporation 1992, $2,000; America the Beautiful 1992, $10,200; Small Business Administration 1993, $12,000) to plant trees and provide impetus for hiring the city's first urban forester, Garland Gatlin, in 1995.

Question 3. How do you get what you want?

Steps E and F. Select Tools, Formulate, and Implement the Management Strategy.
With respect to street trees, the city of Hattiesburg's 2002-2005 plan of goals and objectives outlines what any city would be proud to achieve: "Main Goal – protect existing trees and increase tree cover in Hattiesburg." City street trees and trees within public facilities are to be maintained in a healthy, vigorous condition to provide numerous benefits including shade, wind barriers, improved air quality, and visual relief.

The city's comprehensive urban tree management plan selected tools such as ecologically and horticulturally sound pest and disease control; a high standard of pruning; proper planting and establishment methods; and a timely response to complaints and safety concerns to implement their management strategy. In other words, the city sought to maintain a functional municipal forest that is both healthy and safe, with street tree populations that yield numerous benefits without compromising environmental quality or the well-being of the citizens who live, work, and play there.

Ultimately, Hattiesburg "gets what it wants" by accomplishing their objectives of maintaining mature trees, tree planting, establishing a tree nursery, supplying trees to residents, maintaining young trees, and improving tree ordinances. These ordinances can apply to any city wanting to protect, maintain, and restore its trees, and are, in fact, a good set of objectives and goals for which to strive.

Question 4. Are you getting what you want?

Step G. Evaluate and Revise.
Although street tree inventories can and do occur as a precursor to new community forest management plans, they can also be helpful in evaluating and revising management plans already in place. As discussed above, Hattiesburg used this tool to evaluate their own management plan, and will,

no doubt use it to make any necessary revisions for the future.
As part of the natural resource based plan or overall urban forest management strategy, municipal officials, committees, tree boards and commissions, and other affiliated parties must determine and carefully examine any codes, regulations, ordinances, or laws that may affect, however remotely, the plan or strategy. Any and all codes, regulations, ordinances, or laws must then be addressed, and the plan or strategy altered, prior to approving or initiating any activities.

Some examples of codes, regulations, ordinances, or laws that may be in place in Mississippi communities include:

≈ subdivision ordinances, (exercise power in subdivision design, including physical layout, street standards, utility service, and open space);
≈ zoning regulations, (control land use by dividing the land into different use districts and setting standards for development, including parcel use, lot size, density, street and property line setbacks, and structure size);
≈ building codes, (dictate to what standards structures must adhere, including fire resistance, capacity, size and height, and appearance);
≈ vegetation ordinances, (address undesirable plants, municipal trees, and arborist certification and licensing);
≈ tree protection ordinances, (protect existing trees and other vegetation during development and regulate tree removal by establishing definitions, procedures, penalties, and appeals necessary for enforcement);
≈ special tree, species, and ecosystem regulations and laws, (often require specific guidelines for their mainte-

nance and protection);

- landscape ordinances, (require submission and approval of landscape plans, tree location plans, or new tree planting for new developments or development rehabilitation);
- screening ordinances, (set standards for structural and/or vegetation screening on lot peripheries and vegetated islands within the lot); and
- energy conservation regulations, (reduce wind speed, mitigate urban heat islands, and reduce overall energy use and waste).

Although not all of the above codes, regulations, ordinances or laws will be in effect in, or applicable to, all communities or situations, many will apply and can affect

plans or strategies. Communities should take steps to ensure that the review of all future development includes checking the plan against their Community Forest Management Strategy. Careful examination and attention to detail can help avoid potential conflicts of interest and ensure plan success.

Developing Urban and Community Forestry Ordinances

Need for Urban and Community Forestry Ordinances

To many residents, urban and community forests, no matter what their size, are an important and essential part of the community which provides character and beauty, and influences property values and the quality of life enjoyed by community residents.

One proven tool used by communities striving to attain a healthy, vigorous, and well-managed community forest and protect urban and community trees and woodlands is adoption of local laws through the development and establishment of urban and community forestry ordinances. In their most basic form, ordinances generally seek to provide developers with a framework for preserving and restoring as many trees as possible on a site, often placing an emphasis upon older, larger specimens. Urban and community forestry-related ordinances can also serve to protect and establish green space, delineate and protect buffer zones, maintain and protect urban and community trees, and control non-point source pollution, or mitigate stormwater.

Planning For Urban and Community Forestry Ordinances

All communities have different needs and values regarding their urban and community forestry resources. To some communities, retention of the urban and community forest resource and the proper specifications and standards of urban and community forest restoration through tree planting is a critical need for which ordinances are established. Ordinances, in effect, generally reflect the individuality and values of a community and its residents, values they believe are worthy of protection and essential to maintain their quality of life and provide an environment that is both pleasant and safe. More specifically, urban and community forestry ordinances encourage neighborhood beautification, tree protection and preservation, regulation of development, and restoration of areas through planting and management. Additionally, ordinances serve the purpose of enabling citizens to prevent the spread of tree diseases and regulate sidewalk replacement and utility line clearing work. Finally, urban and community forestry ordinances can enhance the beauty and safety of a community's urban forest because they often require the use of professionals, specify duties of municipal employees, and help control careless management of this important natural resource.

By themselves, urban and community forestry ordinances cannot assure the improvement or maintenance of urban and community trees. Tree ordinances simply provide authorization and standards for management activities which must be integrated into an overall management strategy. Simply put, tree ordinances can assist in the overall proper management of community tree resources.

Effectiveness of Urban and Community Forestry Ordinances

The effectiveness of urban and community forestry ordinances depends upon numerous factors including resident support, opposition, and awareness; adequacy of ordinance enforcement; provisions for environmental limitations that affect tree health, growth, and survival; and availability of financing from local governments to fulfill ordinance requirements.

Although the form, content, and complexity of ordinances may vary widely, an effective tree ordinance should meet the following criteria:

1. Goals should be clearly stated and ordinance provisions should address stated goals. Goals must be clearly stated because they provide the basis for interpreting ordinances and evaluating their effectiveness. Lack of clear, specific goals is a common shortcoming of many tree ordinances.
2. Responsibility should be designated, and authority granted, commensurate with responsibility. In most cases, the most efficient way to manage an urban forest is to have one individual responsible for overseeing all tree-related activities. In smaller communities, it may be necessary to split responsibility between a tree commission, which sets

policy and has administrative duties, and city staff, which is responsible for operations and enforcement.

3. Basic performance standards should be set. Effective performance standards address the urban forest as a whole rather than focusing exclusively on individual trees.
4. Flexibility should be designated into the ordinance. Flexible performance standards can allow responsible parties to make decisions on a case-by-case or site-specific basis.
5. Enforcement methods should be specified. Specifying enforcement methods like fines, jail terms, forfeiture of performance bonds, and tree replacement plantings and consistent enforcement of these methods can help deter offenders.
6. The ordinance should be developed as part of a comprehensive management strategy. A comprehensive management strategy assures the inclusion of appropriate and necessary provisions to protect urban and community forestry resources.
7. The ordinance should be developed with community support. Developing the ordinance within the context of community values and priorities can help gain public support. Many ordinances rely on voluntary compliance to guarantee public support.
8. Effective tree ordinances are connected to local land use planning and zoning. They are also part of the building permit process. Information on ordinance requirements and tree care techniques should be available at the planning office and wherever people apply for building permits.

Recent Trends and Initiatives in Community and Urban Forestry Management

Urban air and water quality remain two of the most critical issues in sustainable environmental planning. Concern over the effects of carbon accumulation in the environment and the potential for long-term climate change have prompted many municipalities to increase their enforcement of urban forestry and landscape ordinances.

Green Laws as they are commonly called have taken on a new significance at both the state and local level, as communities strive to maintain and improve the quality of life for their residents and visitors. Standardizing and strengthening these types of guidelines has the obvious potential to enhance the aesthetics and economic property value of an area, but may also generate additional economic returns in the form of lower maintenance costs and improved public health.

Along with tree ordinances, Green Laws may be crafted in the form of landscape laws and other codes or regulations designed to address land usage, development, and post-construction issues. While they are developed with similar purposes and expected outcomes in mind, agencies responsible for each level of responsibility may vary considerably depending upon a community's size and funding capability.

Some of the most comprehensive examples and strategies for implementing urban Green Laws can be found at the Louisiana State University Web site at www.greenlaws.lsu.edu. Additional recommendations for soil conservation, habitat management, streamside protection, and stormwater management are specifically discussed in Chapters 3 through 6 of this manual.

Carbon Sequestration

Carbon released primarily in the form of carbon dioxide (CO_2) looms as the largest immediate threat to environmental quality worldwide, and efforts to curb its escape into the atmosphere remain a top priority in sustainable community planning. Discharge of carbon-based compounds has been linked to depletion of the Earth's protective ozone layer, and good urban forest management is recognized as one of the best ways that humans can effectively combat carbon release on a large scale.

Plants and animals all release a certain amount of carbon back into the environment as they die and decompose, and are referred to as

carbon "sources." Carbon release and recapture is part of the Earth's natural cycle, and it can be difficult to establish a level at which this natural cycle becomes dangerously imbalanced. Elevated burning of fossil fuels and other industrial energy use is a major cause of carbon release, while natural disturbances like wildfires contribute further to the problem. Vegetation loss from catastrophic storms, drought, and other natural occurrences also creates a negative surplus of carbon that must be offset in some fashion. Unfortunately, burning and landfill burial are too often the solutions chosen to address these excess sources of carbon.

Sequestration is the term used to describe the capture and storage of CO_2 and other harmful compounds [such as nitrous oxide (NO_2) and methane (CH_4)], and prevent their reintroduction into the environment for prolonged periods of time. Methods and locations used for the collection of carbon are referred to as "sinks." Carbon may be trapped and held in a variety of sinks to include:

1. terrestrial (above ground) sequestration,
2. subterranean (geologic or underground burial) sequestration, and
3. submersed (aquatic or oceanic) sequestration.

Terrestrial sequestration involves the capture and storage of CO_2 by plants and soil microorganisms that utilize carbon in their natural life cycles. It is the most environmentally sound method of trapping carbon, and may offer the best long-term solution in preventing the release of unwanted carbon back into the atmosphere. Carbon may be stored in the landscape for varied periods of time due to changes in land use, and the frequency of natural disturbances that alter the forest inventory.

Carbon accumulation in forests and soils does eventually reach a saturation point, beyond which additional sequestration is no longer possible. This happens, for example, when trees reach maturity, or when the organic matter in soils builds back up to original levels before losses occurred. Even after saturation, tree inventories must be continually managed and regenerated to maintain the level of accumulated carbon, and prevent subsequent losses of carbon back to the atmosphere. Thus, it is important to note that urban forestry efforts to sequester carbon are both transitional and limited.

The U.S. landscape currently acts as a net carbon sink, sequestering more carbon than it emits. Two types of analyses that confirm this are atmospheric (top-down methods that measure changes in CO_2 concentrations); and land-based (bottom-up methods that incorporate on-the-ground inventories and terrestrial plot measurements). Net sequestration is described as an "offset," which is the difference between carbon gains and losses. Offsets are measured in teragrams (Tg) for CO_2 in its gaseous state, and in million metric tons in its elemental carbon form (i.e., carbon stored in compounds in trees and other vegetation). One Tg of CO_2 is equivalent to one million tonne of stored carbon.

In 2001, U.S. industrial forests, urban trees, and agricultural soils sequestered an average of 840 Tg of carbon (CO_2 equivalent), which was eventually converted into 230 million tonne (MMT) of measurable stored carbon (carbon equivalent). This offset accounted for approximately 12% of the total U.S. CO_2 emissions from energy, transportation, and other sectors (See the U.S. Inventory of Greenhouse Gas Emissions and Sinks).

Still, the overall carbon sequestration rate in the U.S. has declined by more than 15% since 1990, and it is projected to continue declining due to increasing harvests, land-use changes, and maturing forests. Conversely, since 2001 carbon sequestration rates in urban settings have increased by 67%, and opportunities to perpetuate this trend appear promising. Research has suggested that maximizing urban forest planting and management of existing trees can greatly offset the negative effects of industrial carbon emissions, at least in the short term.

Urban forests in the U.S. currently store more than 700 MMT of carbon. These woodlands are credited with an annual carbon sequestration capacity of 88 MMT of CO_2, and this accounts for nearly 10% of all carbon stored by forestry and agricultural practices combined.

Challenges in Sequestration Research

Establishment of baseline levels that can consistently predict carbon storage rates in diverse urban forests populations may be the most critical challenge. While it was estimated that one acre of planted pine plantation can absorb up to one tonne of carbon per year (or a total of 100 tonne during a 90-year growth cycle), these figures were not automatically transferable to the urban setting. The perpetuity of trees produced in commercial forests differs greatly from that of urban forests due to industrial demand. Urban woodlands are usually much more geographically fragmented, and face a diverse range of environmental factors compared to rural timberlands.

Sequestration rates vary greatly according to the age, composition, and location of forests. Faster growing species in warmer climates tend to acquire a capacity for storage at an earlier age, but are usually shorter-lived, and have less potential for cumulative storage. Longer-lived species generally have a more intensive maintenance requirement, but tend to remain established for longer periods of time, and thus have a better potential for being converted "permanently" into other wood products after they are harvested.

Data reported in 2002 by the Journal of Arboriculture suggested that urban stands of eastern mixed deciduous hardwoods may store a net average of more than 60 pounds of carbon per tree annually, when allowed to grow to maturity without disturbance. Trees targeted in this study were classified as large-growing species with a wide range of growth rates. Factors also considered in storage estimation were the expected life span of each species, and maintenance requirements for trees during

20, 40, and 60-year life spans. Hardwood forests were projected with the capacity to sequester between a minimum of 0.3 and a maximum of 4.07 million tonne per hectare depending upon these multiple factors.

Longevity does not necessarily equate to maximized carbon storage, and certain species such as red maple have been touted for multiple attributes like fast growth, early sequestration age, and storage capacity in relation to life span (e.g., trapping 94 pounds of carbon annually at age 10, then 247 pounds annually at age 20). Regardless of whether forests are deciduous or evergreen, analysts concur that trees should be established for a minimum of 10 years (with a minimum height of 15 to 25 feet for most species) before they can be considered as contributors to carbon offset.

Soil type plays a major role in the growth rate of carbon-trapping vegetation, and is another determining factor in the speed at which carbon or other compounds are allowed to "flux" or leakage back into air and groundwater. The amount of wood fiber removed from pruning, the level of carbon lost through removal of leaf litter, composition of the forest understory, and even the fossil fuel requirement for operation of maintenance equipment are just a few additional factors that play into the complex sequestration scenario. More information on U.S. carbon sequestration estimates and historical trends can be found under the National Analysis and Carbon Sequestration in Agriculture and Forestry Web site at www.epa.gov/sequestration.

Greenhouse gas initiatives (GHG) are not focused solely on CO_2 emissions, but also on NO_2, CH_4, and other organic compounds. While carbon sequestration alone is not currently the most economically profitable of ventures, research is ongoing toward sequencing of the genomes of beneficial microorganisms that help convert carbon-based compounds into renewable fuel sources.

Goals to reach a level of permanence in carbon storage are ambitious and long-term, with states like California already implementing a 100-year plan. Other states are also considering employment of a stratum model similar to the California Urban Forest Reporting Protocol, which introduces the concept of Net Tree Gain (NTG). By planting a minimum of 1.16 trees for each tree removed, the model seeks to achieve a threshold or permanent NTG of 100 trees per 100,000 planted, allowing for mortality. With an increase of 50 million new trees planted incrementally above annual inventory levels, the objective by the year 2025 is to sequester an additional 4.5 MMT of carbon each year.

If proven successful, this plan could initiate a process of actually trading or selling surplus carbon credits produced directly by urban forests. The economic returns remain unclear, but with baseline costs estimated at $150 per MMT to plant new trees, the model projects a net return of between $140 and $553 per MMT of carbon sequestered by each tree over its projected life span.

Chapter 3: Guidelines for Conserving Wooded Areas

Conserving Wooded Areas

Best Management Practices (BMPs) to Conserve Wooded Areas at the Landscape Level

Conservation of wooded areas should be an essential part of any land development project. Conserving and incorporating trees into existing neighborhoods, new developments, and the watershed can lead to more livable communities that retain the integrity and benefits of natural resources and are ultimately more sustainable. Urban and community planners can more easily conserve wooded areas by adopting and following a step-by-step land-use approach that consists of defining goals, conducting an inventory and assessing resources, creating a conservation plan, and identifying and selecting land protection options.

Define Goals

Goals to conserve wooded areas across the landscape should include:

≈ protection and/or restoration of ecological integrity and functions,
≈ protection and promotion of connectivity and continuity of wooded areas across the landscape and political boundaries,
≈ establishment or creation of networks of forest communities as open space,
≈ definition of neighborhood and community boundaries,
≈ concealment of unsightly or incompatible land-use practices, and
≈ protection of wildlife habitat and corridors.

Inventory and Assessment of the Resource

A landscape-level resource inventory that includes a woodland survey, resource assessment, and produces a Comprehensive Landscape Resource Map should be conducted.

The woodland survey and resource assessment consists of:

≈ delineating tree stands,
≈ identifying and classifying wooded areas by type and condition,
≈ assessing ecological functions as well as conservation values of wooded areas within the jurisdiction and adjacent jurisdictions,
≈ identifying, classifying, and assessing other natural resources (i.e., wetlands, farmlands, areas occupied by rare plant and animal species, and projected green spaces), and
≈ identifying watershed, drainage, topography, soil types, existing infrastructures, and areas of significant historical and cultural values.

Following the woodland survey and resource assessment, a Comprehensive Landscape

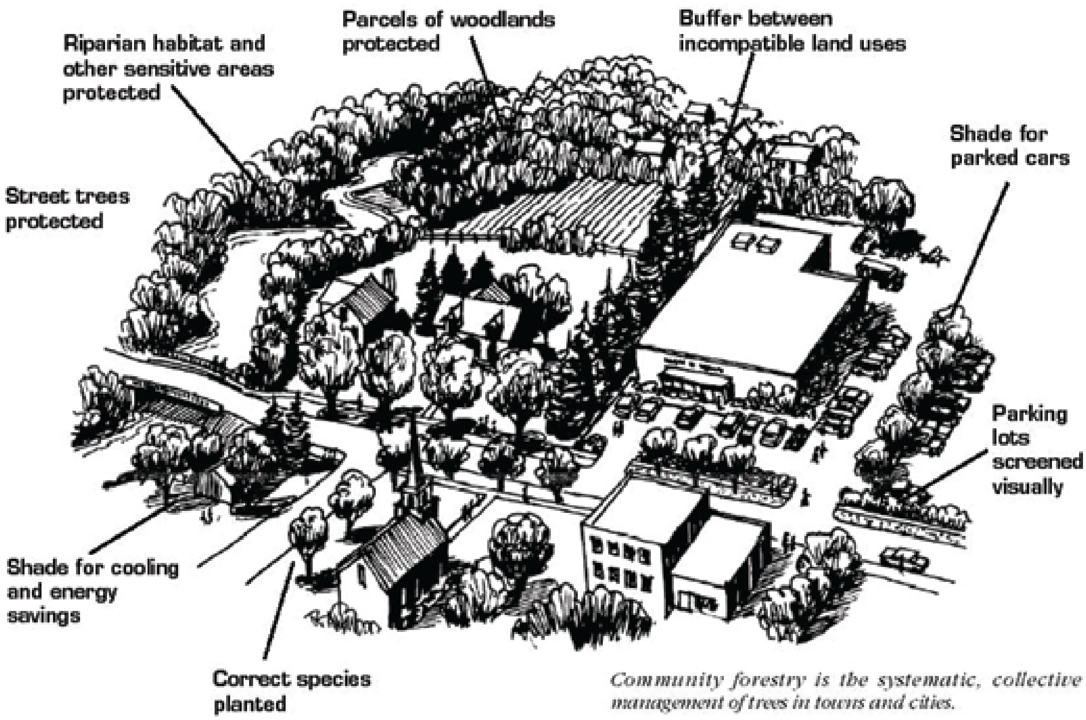

Figure 3-1. Examples of methods to incorporate trees into existing neighborhoods, new developments, and watersheds. Source: Fazio 2003.

Resource Map, containing all pertinent survey and assessment information, can be created.

Creating a Conservation Plan

A conservation plan, based on the resource inventory and assessment data and Comprehensive Landscape Resource Map should be created by:

≈ identifying and locating wooded areas,
≈ identifying and locating sites for main transportation systems and utility infrastructure,
≈ selecting wooded areas to conserve, including:
- larger tracts or remnant wooded areas,
- wooded areas that have potential to be connected to others,
- wooded areas with significant ecological functions and conservation values,
- wooded areas occupied by rare plant and animal species,
- areas with reforestation and restoration potential.

≈ identifying developable areas.

Once all of the above areas have been identified and recorded on the Comprehensive Landscape Resource Map, the map should be entered in a Geographic Information System (GIS) and shared with other local and regional units of government, developers, builders, and private organizations to promote continuity and connectivity of wooded areas across the landscape and enhance coordination and partnerships among all stakeholders. Developers and builders should also be included in this process and be informed of conservation goals and wooded areas set aside for conservation.

Identify and Select Land Protection Strategies

Following the development of a Comprehensive Landscape Resource Map and identification of wooded areas to conserve, appropriate land-protection options should be selected. Options available to local and regional units of government include use of zoning and subdivision ordinances and consideration of other conservation and protection options.

When drafting ordinances to promote conservation of wooded areas:

≈ gather input from developers, builders, and citizen organizations,
≈ integrate conservation values in zoning codes and policies,
≈ identify developable subdivisions and conservation zoning districts in the comprehensive plans,
≈ determine the type of development to be allowed using information contained in the Comprehensive Landscape Resource Map,
≈ promote flexible subdivision ordinances that encourage variable lot sizes and configurations, street width and setbacks according to traffic, utility types and easements, and creative development plans,
≈ draft local woodland and tree-protection ordinances for both public and private property,
≈ provide incentives to reduce impervious surfaces (including reduced road width, setbacks, parking lots, or provision of additional lots, tax incentives, and public recognition or awards),
≈ promote the use of joint utility easements and trenches for underground utilities and rights of way for overhead lines,
≈ create a local natural resource advisory board to foster participation of community organizations including citizens, nonprofit organizations, developers, builders, and contractors,
≈ create conservation overlay districts in the jurisdiction using comprehensive plans and zoning ordinances, and determine urban growth boundaries for infrastructure (i.e., new water and sewer lines),
≈ provide incentives to promote or mandate implementation of conservation designs such as conservation zoning designs, open space designs, conservation subdivision designs, and cluster development designs,

- ≈ set up conservation standards based on sound protection options of wooded areas (e.g., promotion of the conservation of 50 to 70% of wooded areas in residential zoning districts as natural wooded open space),
- ≈ promote new and flexible approaches to conservation (e.g., dedicate 15 acres of land for park, playground, and public open space for every 1,000 residents or prohibit development on wooded areas of 10 acres or larger), and
- ≈ provide a management strategy to maintain and enhance the quality of protected wooded areas (the strategy should have an education component for the public and include frequent assessments of tree and forest health, fire hazards, and wood utilization).

Other conservation and land protection options that have been developed to assist landowner and local units of government include:

- ≈ conservation easements,
- ≈ land-retirement programs,
- ≈ property tax-relief programs,
- ≈ restoration cost-share programs,
- ≈ registry programs,
- ≈ land transfers,
- ≈ deed restrictions,
- ≈ mutual covenants,
- ≈ management agreements,
- ≈ land donations,
- ≈ land sales to conservation buyers,
- ≈ land exchanges, and
- ≈ transfer of development rights.

BMPs to Conserve Wooded Areas at the Subdivision Level

Define Goals

Goals to consider in land development should include:

- ≈ conservation of green corridors,
- ≈ conservation of wooded areas as natural open space or a conservancy area, and
- ≈ protection of individual trees.

Inventory and Assessment of the Resource

Resource inventory and assessment at the subdivision level should follow the same steps as those conducted at the landscape level, but at the smaller scale of the subdivision. Generally, the resource inventory and assessment for a subdivision is accomplished in three steps:

- ≈ evaluate existing resource information (obtained from larger scale resource inventory and assessments, including any local zone and tree preservation ordinances),
- ≈ conduct site review and survey trees (including identification and location of wooded areas and other natural resources, and delineation of potential wooded areas to protect).
  - The site review and tree survey is conducted by:
    - obtaining aerial photography (available through tax assessor),

- incorporating remote sensing data,
- identifying and locating wooded areas and other land types, and
- delineating potential wooded areas to protect, such as:
  - wooded areas protected or identified by local, state, and federal laws, policies, and/or regulations (i.e., wetlands, greenways, and natural areas),
  - wooded flood plains, wooded stream corridors, steep wooded slopes, and buffer zones, and
  - remnant tracts of wooded areas at least one acre in size with healthy trees.

≈ create a Comprehensive Landscape Resource Map for the subdivision that will be used as the basic tool from which all decisions related to the development will be made.

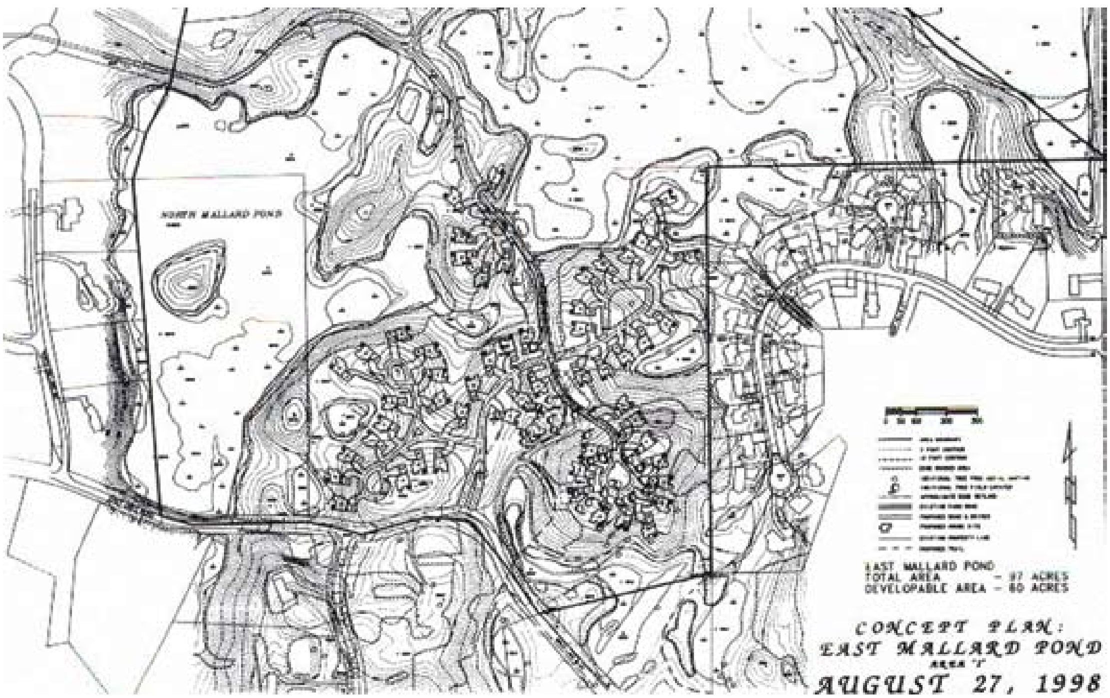

Figure 3-2. A comprehensive Landscape Resource Map of a subdivision such as this example from North Oaks, Minnesota shows location of wooded areas, individual trees, water bodies, proposed developable sites, and conservancy areas. Source: Minnesota DNR 2000.

Create a Wooded Area Protection Plan

Using the subdivision Comprehensive Landscape Resource Map, develop a protection plan which includes:

≈ selection and delineation of wooded areas to protect, considering the following steps:
  - record location of wooded areas to be protected based on the goals and information provided on the resource map,
  - record all areas likely to be adversely impacted during construction,
  - record areas that can be used for reforestation and/or restoration, and
  - locate and delineate developable and buildable sites, and

≈ submission of development plan for approval which should be collectively reviewed by the developer and the county, city, or township planner.

Select a Protection Method

Once the development plan is approved, the developer and/or builder should select the protection method that consists of several steps:

≈ determine the protected root zone, which is:
  - off limits to all construction activities, and
  - should be determined and protected prior to construction.

≈ mark the protected root zone,

≈ determine the grading area and method,

≈ define reforestation plan and method (should select suitable tree species planting design to meet intended goals), and

≈ record trees to be transplanted to other locations.

Monitor and Evaluate the Conservation Plan

If a conservation plan is to succeed, participation and commitment of all parties involved in the development project is essential. Plan monitoring and evaluation should include:

≈ education of those involved regarding goals and tree protection measures,

≈ site inspection which includes frequent visits to the site to check for violations of tree protection plans, and

≈ financial penalties for violations (may be monetary or replacement of trees).

BMPs to Protect Trees at the Lot Level: New Construction, Remodeling, and Redevelopment

Recommended Practices

Proactive planning and use of appropriate approaches and tools can guarantee greater protection and conservation of wooded areas and trees during construction. To achieve protection goals, the following steps should be taken:

≈ Define goals, including:
  - protection of wooded areas and trees from construction damage,
  - compliance with zoning regulations, conservation easements, and

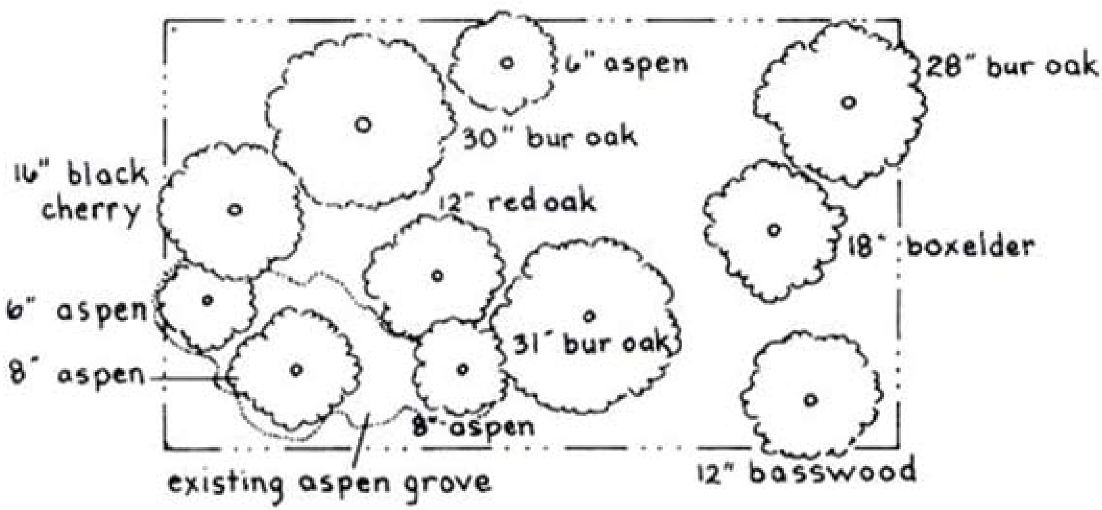

Figure 3-3. A resource map at the individual lot level shows the location of the wooded area and individual trees, species composition, and diameter of trees at breast height. Source: Minnesota DNR 2000.

- maintenance and enhancement of community aesthetics and property values.

≈ Inventory and assess trees by:
- obtaining or drawing a boundary map of the lot,
- recording the location of all trees and wooded areas,
- conducting a tree survey and health assessment, including:
  - tree species and age class, and
  - health condition (i.e., trunk form, crown form, and overall condition), and
- recording tree survey and health assessment information on the Comprehensive Landscape Resource Map.

≈ Select trees or groups of trees to protect, using these criteria:
- select trees or groups of trees as needed to comply with any local tree preservation ordinances,
- select trees and wooded areas found within conservation easements or covenants,
- select trees that are suitable to the site conditions (e.g., native species and trees with desirable growth characteristics),
- select trees that provide direct benefits (e.g., wildlife habitat,

shade, windbreak, screening, privacy, etc.),
- select trees that are connected to other trees (e.g., groups or lines of trees) on adjoining property to achieve connectivity,
- pay particular attention to younger trees that may have greater tolerance for site disturbance during construction,
- identify protected trees with colored ribbon, and
- record location of tree and species name on the Comprehensive Landscape Resource Map.

≈ Select building sites and construction zones and identify other areas such as setbacks, easements, and areas dedicated to conservation.

≈ Create a tree protection plan by determining and delineating the protected root zone.

≈ Select and implement tree protection method, and

≈ Monitor and evaluate by:
- visiting the building site to check for any disturbance or violation of the tree protection plan,
- calling for a tree survival and replacement plan to be extended from two to five years following construction,
- imposing financial penalties, and
- making referrals to other clients for builders or contractors who do an exceptional job of protecting trees during construction.

D.R. Hartel, USDA Forest Service, www.urbanforestrysouth.org

Chapter 4: Guidelines for Protecting Urban and Community Streams

Protecting Urban and Community Streams

Areas containing urban streams must be given special consideration because development in these areas can have a profound impact on stream hydrology, morphology, water quality, and biodiversity. Because development is often a gradual process spanning decades and wide regions of the landscape, stream protection strategies must address the comprehensive protection of stream quality throughout the entire development process.

A local urban stream protection strategy has six primary components roughly corresponding to each stage of a normal development cycle from zoning, planning, site design, construction, stabilization, to final occupancy. These components are watershed-based zoning or land use planning, protection of sensitive areas, establishment of buffer networks, reduction of impervious cover in site design, limitations on erosion during construction, quantity and quality treatment of stormwater runoff, and maintenance of stream protection measures.

Watershed-based Zoning or Land Use Planning

To a large extent, the future quality of an urban stream is determined by community land-use decisions. Therefore, careful consideration must be given to these streams during the zoning planning process.

The underlying premise of watershed-based zoning holds that impervious cover, not population density, is a superior measure of growth impact. Based upon the variable of impervious cover, it is possible to classify and manage streams within a community using the sequence of steps involved in watershed-based zoning below.

Step 1. Conduct a comprehensive physical, chemical, and biological stream inventory to assess the current quality of urban and community streams.

Step 2. Refine/verify impervious cover/stream quality relationships and identify sensitive stream systems.

Step 3. Measure and map existing and future impervious cover at the subwatershed level and, if possible, project future impervious cover growth based on the build-out of existing zoning.

Step 4. Designate subwatersheds into one of three stream quality categories (sensitive, degrading, non-supporting), based on growth patterns and attainable stream quality under existing environmental conditions and the ultimate level of impervious cover.

Step 5. Modify the existing master plan to meet subwatershed targets and assure that future growth and impervious cover is compatible with the designated stream classification for each subwatershed.

Step 6. Adopt specific stream protection strategies for each subwatershed (including, but not limited to, watershed or site limits on impervious cover, BMP selection criteria, stream buffers, land acquisition, or other protection measures).

Step 7. Incorporate any management priorities that may arise from larger watershed planning efforts (e.g., at the scale of watershed, subbasin, or basin).

Step 8. Implement long-term monitoring and enforcement programs to provide management feedback and assess whether the stream management strategies are achieving stream quality goals set for each subwatershed.

Specific examples of stream protection strategies from watershed-based zoning are included in Appendix C.

Protection of Sensitive Areas

Sensitive areas such as wetlands, flood plains, steep slopes, critical habitats, shorelines, and mature forests can and should be protected through the development, adoption, and enforcement of ordinances that prevent development in these areas. Ordinances should describe how each area will be delineated on-site, and what protective measures will be taken during all stages of any development process. Additionally, it is a good idea to establish a set of performance criteria to protect these areas.

Establishment of Buffer Networks

There are a number of reasons for creating urban riparian forests or urban stream buffers. In both residential and commercial areas, runoff can contain fertilizers, herbicides, pesticides, and other pollutants that can be filtered out by plant roots and broken down by microorganisms and, ultimately, help add and maintain biodiversity in the urban and community environment.

Benefits of Urban and Community Riparian Forests and Stream Buffers

The buffer's primary value is physical protection of the stream channel from future disturbance or encroachment. A network of buffers acts as a right-of-way for a stream and functions as an integral part of the stream ecosystem but also provides many additional benefits as outlined in Appendix C. In many regions, these benefits are amplified when the streamside management zone is kept in a forested condition.

One of the most important benefits of urban and community streamside buffers is their potential ability to remove harmful pollutants from urban stormwater runoff. On the basis of performance data from related vegetative systems, it is possible to estimate the pollutant removal capacity of an urban riparian or stream buffer. A three zone buffer system like the one described below has the potential to achieve the following pollutant removal rates:

- ≈ sediment – 75%,
- ≈ total nitrogen – 40%,
- ≈ total phosphorus – 50%,
- ≈ trace metals – 60 to 70%, and
- ≈ hydrocarbons – 75%.

The ability of a particular buffer to remove pollutants, however, depends on many site-specific factors (Appendix C). In the case of stormwater runoff treatment, stream buffer use should be restricted to those conditions where site-specific factors assure reliable pollutant removal.

Performance Criteria for Stream Buffers

Planning, design, and maintenance of buffers largely affects the ability of a buffer to realize its many benefits. Examples of practical performance criteria are listed below to govern buffer size, management, crossings, and stormwater treatment. The 10 example criteria include:

1. Minimum total buffer width–According to a national survey, urban stream buffer sizes range from 20 to 200 ft. in width, with a median of 100 ft. In general, a minimum base width of at least 100 ft. (e.g., 3 to 5 mature trees wide on each side of the channel) is recommended for adequate stream protection.
2. Three-zone buffer system–Riparian or stream buffers are typically broken up into three zones, the Undisturbed Forest or Streamside Zone (Zone 1),

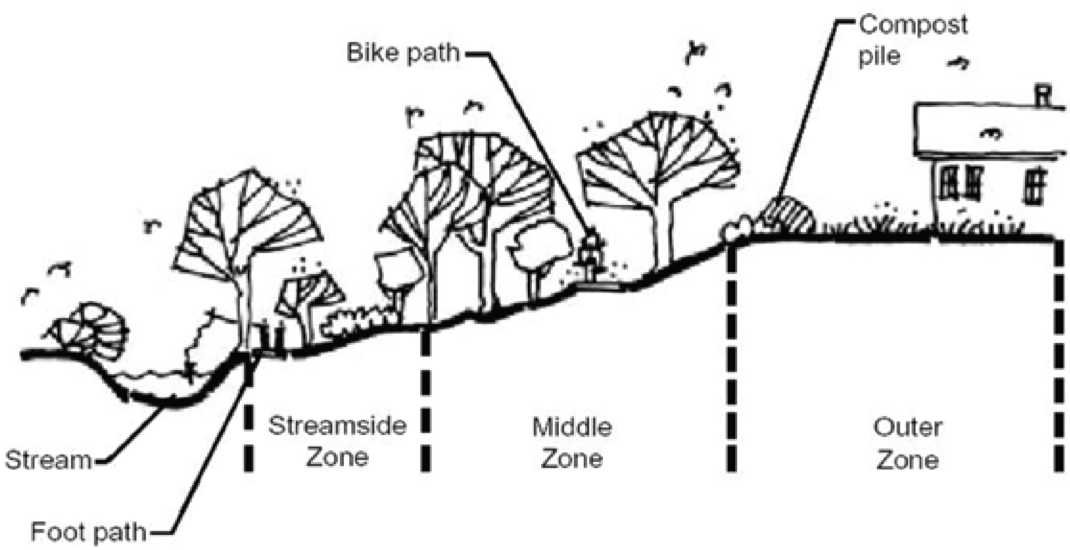

Figure 4-1. Three zone urban buffer system. Source: MDEQ 1994 .

the Managed Forest or Middle Zone (Zone 2), and the Runoff Control or Outer Zone (Zone 3), each of which performs a different function, has a different width, vegetative target, and management scheme (Figure 4-1) (see Appendix C for full descriptions). Prescriptions are usually based on climatic zone, soil types, soil drainage characteristics, and available and desired tree and shrub species. As an example, on a poorly drained site in the South, recommendations may call for:

≈ Zone 1—river birch and black willow for bank stabilization,

≈ Zone 2—cherrybark oak and loblolly pine as filtering mechanisms, and

≈ Zone 3—maidencane and gray dogwood for grass and shrub runoff control. For prescriptions on various soil types and drainage capacities and planting recommendations for urban riparian forests in the South see Appendix C.

3. Pre-development vegetative target—Generally, the vegetative target should be based on the natural vegetative community present in the floodplain, as determined from reference riparian zones.

4. Buffer expansion and contraction—The average width of Zone 2 can be expanded to include:
   - ≈ the full extent of the 100-year floodplain,
   - ≈ all undeveloped steep slopes (greater than 25%),
   - ≈ four additional feet of buffer for each 1% increment of slope above 5%, and
   - ≈ any adjacent delineated wetlands or critical habitats.

   The buffer can also be contracted to accommodate unusual or historical development patterns, shallow lots, stream crossings, or stormwater ponds.
5. Buffer delineation—Three key decisions must be made when delineating buffer boundaries.
   - ≈ At what mapping scale will streams be defined? The traditional scale is the bluelines present on the United States Geological Service (USGS) 7.5 minute quadrangle maps 1:24,000 (1 in=2,000 ft.).
   - ≈ Where does the stream begin and the buffer end? Generally, the stream origin is the point where an intermittent stream forms a distinct channel.
   - ≈ From what point should the inner edge of the buffer be measured? Inner edge can be measured from the centerline of small first- or second-order streams and from the top of each streambank for third- and higher order streams.
6. Buffer crossings—Provisions must be made for linear forms of development that must cross the stream or buffer such as roads, bridges, fairways, underground utilities, enclosed storm drains, or outfall channels. Performance criteria such as crossing width, crossing angle, crossing frequency, and crossing elevation should be used to minimize impact to the continuity of the buffer network and fish passage.
7. Stormwater runoff—Buffers can be an important component of the stormwater treatment system at a development site. This role is discussed later in the Section "Treatment of Stormwater Runoff."
8. Buffers during plan review and construction—During each stage of the development process, limits and uses of stream buffer systems should be well-defined.
9. Buffer education and enforcement—Creating high buffer visibility and encouraging greater buffer awareness and stewardship among adjacent residents will help protect the integrity of a buffer system. Steps that will aid in increasing visibility and awareness include:
   - ≈ marking buffer boundaries with permanent signs that describe al-

lowable uses,
- educating buffer owners about benefits and uses of buffers with pamphlets, streamwalks, and meetings with homeowners associations,
- ensuring that new owners are fully informed about buffer limits/uses when property is sold or transferred,
- engaging residents in a buffer stewardship program that includes reforestation and backyard "bufferscaping" programs, and
- conducting annual bufferwalks to check on encroachment.

10. Buffer flexibility—Incorporating several simple measures into buffer ordinances, such as maintaining buffers in private ownership, buffer averaging, and density compensation, variances, and conservation easements will help alleviate concerns that buffer requirements could represent an uncompensated taking of private property.

Ordinances for Stream Buffers

To better utilize stream buffers as specific planning tools to protect stream quality and aquatic habitat, ordinances specifying the size and management of the stream buffer should be drafted. The model ordinance provided in Appendix C includes 10 sections that provide suggested language or technical guidance to create the most effective stream buffer zones possible. While much of the model is based on Baltimore County, Maryland's regulations for the water quality, stream, wetland, and floodplain protection, additional features and language have been added in certain sections to enhance the protective functions of the proposed stream buffer.

The language in the sample model ordinance is only intended to provide suggestions for possible wording of a community's own buffer regulation; it is not meant to be adopted word-for-word. Local situations and concerns will dictate what modifications of the ordinance language will be required. In areas with coastal and estuarine habitats, location- and vegetation-specific language should be added. Coastal and estuarine areas will also want to address important offshore features such as shellfish beds and migratory bird nesting areas that are influenced by nutrient and pollutant runoff. Additionally, regions may adjust buffer width sizes according to rain fall amounts or other climatic variables. Finally, political situations within a community may also influence the final choice of buffer width standards, making flexibility in stream buffer zone establishment very important.

While the wording of buffer regulations is flexible, several features were determined to be integral in developing the most effective ordinance possible:
- The establishment of a minimum stream buffer width. A width of at least 100 feet is recommended to recognize all the benefits that the stream buffer can provide.
- The creation of a three-zone buffer system with the functions, widths, vegeta-

tive targets, and management schemes for each zone explained in detail.

≈ Language that creates the ability to expand the buffer to include the 100-year floodplain, steep slopes, and any adjacent delineated wetlands or critical habitats.

≈ A thorough explanation of the limits and uses of the stream buffer system and requirements expected for any development plan during the entire development process—from initial plan review through construction.

≈ A system to permanently mark the buffer, both physically on-site, and in the land records, should be enacted.

≈ A designated management system for the buffer, detailing permitted and restricted uses within the buffer, and an educational program that guarantees future residents know about the buffer.

≈ Any waivers or variances which may be granted regarding the buffer should be explained in detail to avoid legal challenges.

≈ Maintenance guidelines and enforcement procedures for buffer violations should be included.

A strong buffer ordinance is only the first step to preserving stream buffers. Communities will also need an effective buffer program that includes the stream buffer performance criteria previously discussed to manage buffers and enforce buffer regulations. Additionally, during the construction phase, communities must make sure that the clearing and grading permit is well-integrated with the forest buffer application. Following construction, programs educating citizens about the importance of the buffer and how to manage it, can help preserve the buffer's integrity.

Fred Faulk, MSU

Chapter 5: Guidelines for Land Developers and Contractors

Guidelines for Construction Sites

Development areas such as residential subdivisions should utilize low impact development principles acknowledging the roles of trees in the planning process. Trees are relatively inexpensive and very effective in preventing on-site erosion. Beyond just reducing the impacts of rainfall they, along with other vegetation on-site, reduce the velocity of stormwater runoff. Tree roots hold soil in place and also increase water infiltration.

Disturbance

When undertaking a construction project, the goal should always be to disturb the smallest area possible for the shortest time period. During the course of a project, disturbed areas should be revegetated with native species as soon as possible. Both temporary and permanent seeding is most often required. Temporary seeding is the planting of fast-growing annual grasses to hold the soil in place in areas that will not be disturbed again for 30 or more days. After this stabilizing process is initiated, plans should be made for more permanent seeding. A list of recommended species and seed choices for Mississippi can be located in Appendix D.

In many cases, additional cultural treatments are required to promote the growth of vegetation. Examples include topsoil replenishment, soil scarification, aeration, fertilization, and irrigation. Soils that cannot be seeded in the off season should be mulched to provide protection until seeding can be initiated. Mulch holds moisture, dampens temperature extremes, and retards erosion on steep slopes during seed establishment. In larger areas with a high potential for erosion, the cost of erosion and sediment controls greatly increase. Therefore, it is sensible to keep on-site vegetation disturbance to a minimum.

Vegetative Preservation

Where possible, all vegetation should be preserved on-site to function as a buffer zone in public areas. This is particularly important for trees since they are more expensive to establish after development and harder to reestablish according to the size and characteristics (e.g., height, form) of the original trees. In addition, trees also serve as a buffer among themselves, thus enhancing their chances for survival.

Steps to prevent encroachment into the buffer zone during construction include:

≈ marking buffer limits on all plans used during construction,

≈ conducting a preconstruction stakeout of buffers to define limit of disturbance,

- ≈ marking limit of disturbance with silt or snow fence barriers and signs to prevent the entry of construction equipment and stockpiling, and
- ≈ familiarizing contractors with limit of disturbance through a preconstruction walk-through.

Sensitive Areas

When possible, sensitive areas should not be disturbed. These areas include steep and/or unstable slopes, land upslope from surface waters, areas with erodible soils, and existing drainage channels. There may also be unique areas or floral and faunal habitats on the property that warrant special attention.

Erosion Controls

There is a strong correlation between pervious, vegetated ground space and reduced stormwater runoff. When possible, construction site runoff should be spread out over all buffer zone lengths. Specific recommendations call for minimums that include:

- ≈ 15-foot wide buffer zone for preserved vegetation, and
- ≈ 150-foot buffer zone adjacent to perennial streams and water bodies.

Divert upslope water around disturbed areas and slow rainfall runoff velocities to avoid erosion. Transport runoff down steep slopes through channels lined with natural vegetation or, if absolutely necessary, through piping.

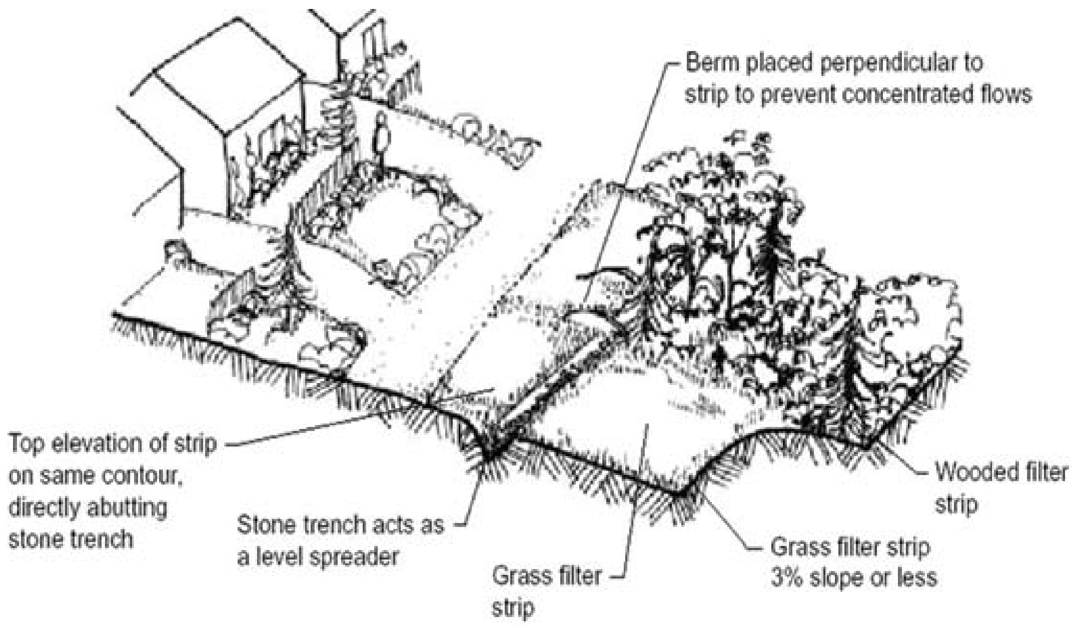

Figure 5-1. Perspective view of vegetative filter strips. Source: MDEQ 1994.

Vegetative Filter Strips

Vegetated filter strips or buffers are areas of either natural or established vegetation that are maintained to protect the water quality of neighboring areas (Figure 5-1). Buffer zones reduce the velocity of stormwater runoff, provide an area for runoff to permeate the soil, contribute to ground water recharge, and act as filters to catch sediment. The reduction in velocity also helps prevent soil erosion. Vegetated buffers can be used in any area that is able to support vegetation, but they are most effective and beneficial on floodplains, near wetlands, along streambanks, and on steep, unstable slopes. They are also effective in separating land use areas that are not compatible, and in protecting wetlands or water bodies by displacing activities that might be potential sources of non-point source pollution.

Vegetated buffers require plant growth before they can be effective, and land on which to plant the vegetation must be available. If the land cost is very high, buffer zones might not be cost-effective; therefore, it is important to conserve and maintain native vegetation on any land whenever possible. Although vegetated buffers help protect water quality, they usually do not effectively counteract concentrated stormwater flows to neighboring or downstream wetlands.

Mulching

Mulching is a temporary erosion control practice in which materials such as grass, wood chips, wood fibers, or gravel are placed on exposed or recently planted soil surfaces. Mulching is highly recommended as a stabilization method and most effective when used in conjunction with vegetation establishment. In addition to stabilizing soils, mulching can reduce stormwater runoff velocity. When used in combination with seeding or planting, mulching can aid plant growth by holding seeds, fertilizers, and topsoil in place, preventing birds from eating seeds, retaining moisture, and insulating plant roots against extreme temperatures.

Mulching might delay seed germination because the cover changes soil surface temperatures. Mulches themselves are subject to erosion and may be washed away in a large storm, and maintenance is necessary to make certain that mulches provide effective erosion control.

Mulching effectiveness varies according to the type of mulch used. Soil loss reduction for different mulches ranges from 53 to 99.8%. Water velocity reductions range from 24 to 78%. In addition, studies have shown that mulching provides a high rate of sediment and nutrient pollution prevention. Seeding or mulching also adds value to a site that more than offsets the cost of seeding or mulching in the eyes of developers, real estate agents, and home buyers. Costs of seed and mulch average $1,500 per acre and range from $800 to $3,500 per acre.

Inspection and Maintenance

To maintain the effectiveness of construction site stormwater control BMPs, regular inspection of control measures is essential. Generally, inspection and maintenance of BMPs can be categorized into two groups—expected routine maintenance and nonroutine (repair) maintenance. Routine maintenance refers to checks performed on a regular basis to keep the BMP in good working order and aesthetically pleasing. In addition, routine inspection and maintenance is an efficient way to prevent potential nuisance situations (e.g., odors, mosquitoes, weeds), reduce the need for repair maintenance, and reduce the chance of polluting stormwater runoff by finding and correcting problems before the next rain. Nonroutine maintenance refers to any activity not performed on a regular basis, including, but not limited to, major repairs after a violent storm or extended rainfall, or replacement and redesign of existing control structures. In addition to maintaining the effectiveness of stormwater BMPs and reducing the incidence of pests, proper inspection and maintenance is essential to avoid the health and safety threats (like downstream flooding, property damage, injury, and death) inherent in BMP neglect.

The effectiveness of BMP inspection is a function of the familiarity of the inspector with each particular BMP's location, design specifications, maintenance procedures, and performance expectations. Documentation should be kept regarding the dates of inspection, findings, and maintenance and repairs that result from the findings of an inspector because such records are helpful in maintaining an efficient inspection and maintenance schedule and provide evidence of ongoing inspection and maintenance.

Guidelines for Streets, Medians, Parking Lots, and Shopping Centers

In urban and community areas, trees and other vegetation can be used as a component of stormwater management for medians, streets, parking lots, and shopping centers.

Site Factors for Trees on Streets, Medians, Parking Lots, and Shopping Centers

Trees planted between paved traffic lanes (i.e., medians), parking lots, and shopping centers usually endure harsh conditions. Problems include compacted soils that often lack appropriate nutrients for tree growth. In addition, these soils may be excessively drained because of the convex shape of the land or poorly drained from a concave form. Trees that grow naturally in bottomland conditions in Mississippi are suited to urban sites because they have adapted to low oxygen and/or compacted soils. Root space is often the most limiting factor for urban trees. Therefore, providing space for roots to grow and expand is critical and can be provided in grids or channels and connected to buffers, natural areas, and rain gardens. Each potential planting site should have an individual assessment and species recommendation since micro-site conditions vary widely, and numerous species are suitable depending on objectives. A list of recommended uses for native tree species suitable for urban and community forestry activities in the Southeast is located in Appendix D.

Growing Space for Trees on Streets, Medians, Parking Lots, and Shopping Centers

Above ground portions of trees must be restricted in size and shape to avoid obstructing pedestrian or driver viewing, and below ground portions must be restricted to a size that will not exceed the available planting area. Upright, vase-like, or oval crowns are preferred over weeping, rounded, spreading, and pyramidal forms (Figure 5-2). Picking the appropriate tree species and proper placement will avoid higher maintenance costs, such as periodic

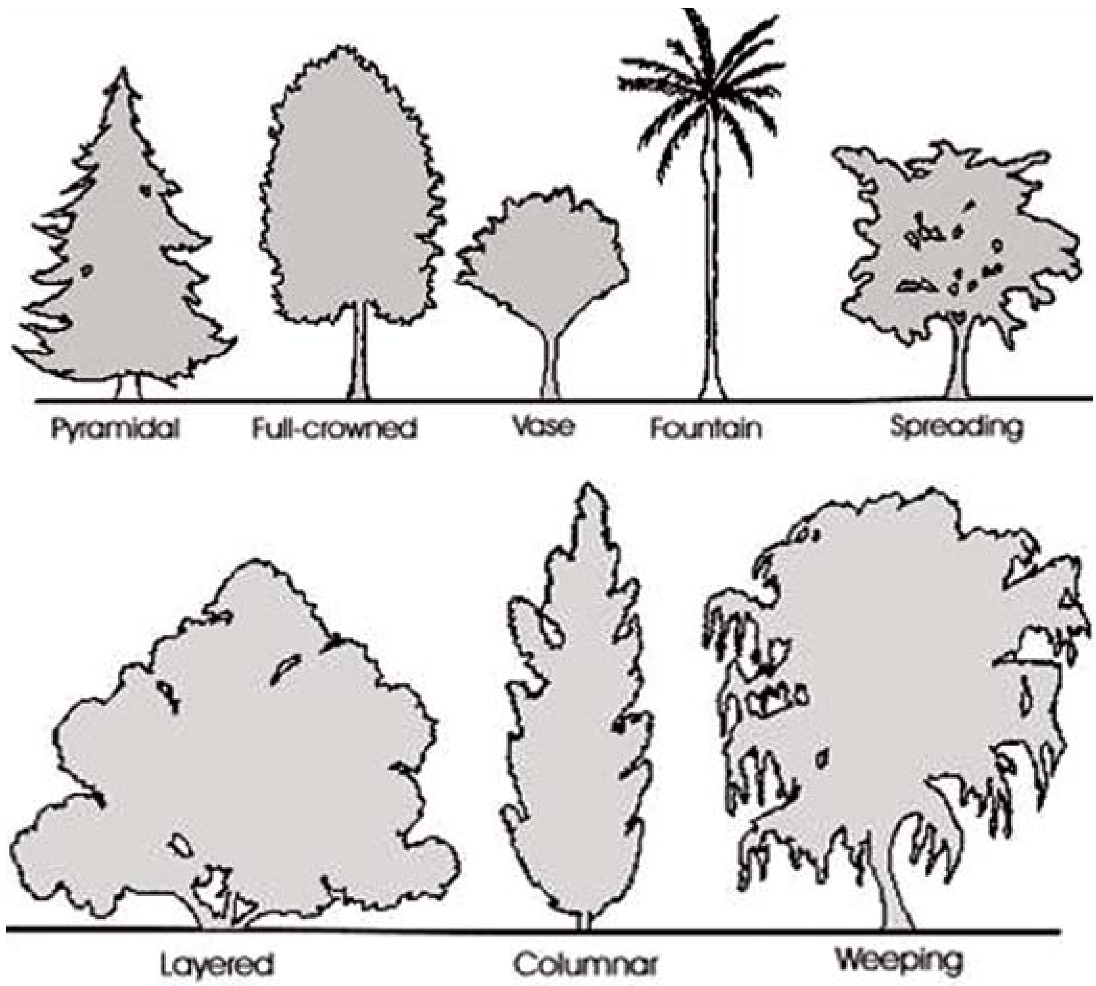

Figure 5-2. Illustration of variety of tree growth forms and sizes. Source: ISA 2000.

pruning, or, in some cases, tree removal and replacement. A list of physical characteristics for native tree species suitable for urban and community forestry activities in the Southeast is located in Appendix D.

Environmental Considerations for Trees on Streets, Medians, Parking Lots, and Shopping Centers

Trees must be resistant to air pollution from vehicles and nearby industries. Planting a variety of trees will increase diversity, with obvious wildlife and aesthetic benefits. Also, a diverse median forest will lessen the chance of widespread losses from insects or diseases. Trees also need to be wind resistant since vegetation planted on streets, medians, parking lots, and shopping centers will often exist in isolation or in small groupings, thereby leaving them vulnerable to windthrow. Trees in urban areas also need to be somewhat drought resistant. Ambient temperatures are known to be higher in developed areas, thus creating additional stress on trees and other plants. Tolerant species will persist better during dry periods and also require less watering by maintenance crews. A list of environmental characteristics and tolerances for native tree species suitable for urban and community forestry activities in the Southeastern United States is located in Appendix D.

Maintenance of Trees on Streets, Medians, Parking Lots, and Shopping Centers

By promoting the establishment and growth of trees on medians, maintenance of these sites should be a consideration. With established tree stands, there will be a shading effect on the understory, resulting in the reduction of mowing required on medians. Where hardwoods are planted, problems may occur with leaf litter that carries off the median. However, most of the leaf fall will be recycled back into the site as nutrients for the stand of trees.

Recommended Tree Species for Streets, Medians, Parking Lots, and Shopping Centers

An extensive list of trees for medians in Tennessee has been developed. Most of these tree species are also appropriate for Mississippi. Lists of native tree species suitable for urban and community forestry activities and classified by recommended use, physical characteristics, and environmental characteristics and tolerances are included in Appendix D.

Best Management Practices for Tree Selection and Placement on Streets, Parking Lots, and Shopping Centers

Finally, before the question of which tree to plant can be answered, a number of factors need to be considered. When selecting trees for placement on streets, parking lots, and shopping centers, the following questions should be asked and answered:

≈ Why is the tree being planted? Do you want the tree to provide shade, fruit, or seasonal color, or act as a windbreak or screen? Maybe more than one of the above?

≈ What is the size and location of the

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planting site? Does the space lend itself to a large, medium, or small tree? Are there overhead or below ground wires or utilities in the vicinity? Do you need to consider clearance for sidewalks, patios or driveways? Are there other trees in the area?

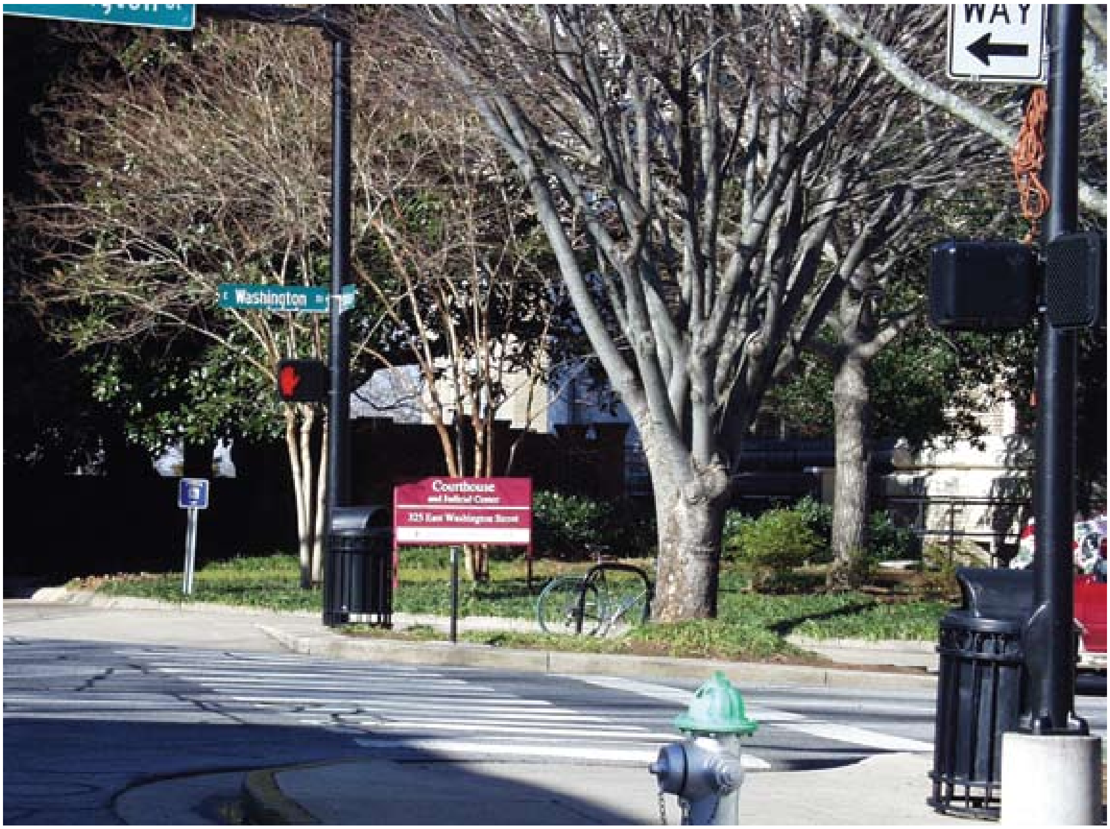
≈ What type of soil conditions exist? Is the soil deep, fertile, and well-drained or is it shallow, compacted, and infertile?

≈ What type of maintenance are you willing to provide? Do you have time to water, fertilize and prune the newly planted tree until it is established or will you be relying on your garden or tree service for assistance?

≈ Can trees be planted as a rain garden for the purpose of on-site water treatment? If so, plant at or below grade and create curb cutouts or other inflow mechanisms. Refer to Appendix D for appropriate tree and plant species.

Asking and answering these and other

questions prior to the actual selection process will help you determine the right tree for the right place. If, however, you have any difficulty answering any of these questions, contact your local ISA Certified Arborist, tree care professional, garden center, or county extension agent for assistance. Their assistance will help you to plant the right tree in the right place. Remember, it is far better to get others involved early and make the right decision, than to avoid having to call them later to ask if you made the wrong decision.



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Chapter 6: Guidelines for Controlling Stormwater with Urban and Community Trees

Urban and Community Stormwater Pollution

Development in urban and suburban areas transforms snow and rain (aka stormwater) into inadvertent vehicles for pollution, making stormwater one of the most significant water pollution problems in the United States. Many surfaces in our metropolitan areas are impervious, preventing precipitation from being absorbed by the soil, increasing the volume and velocity of water flowing over and off the land surface, causing larger and more frequent floods, and increasing erosion of stream beds and banks.

Additionally, impervious surfaces are often coated with unpleasant and sometimes hazardous materials (i.e., sediments, toxic metal particles, pesticides, herbicides and fertilizers, oil, gasoline and grease, harmful viruses and bacteria, excess nutrients and dust, wastepaper, and trash) resulting from our daily activities. These substances contaminate precipitation runoff as it flows across the land surface, eventually entering the waters we use for drinking, bathing, and recreation (Figure 6-1). Even in urban areas, this water is also used for agricultural or home

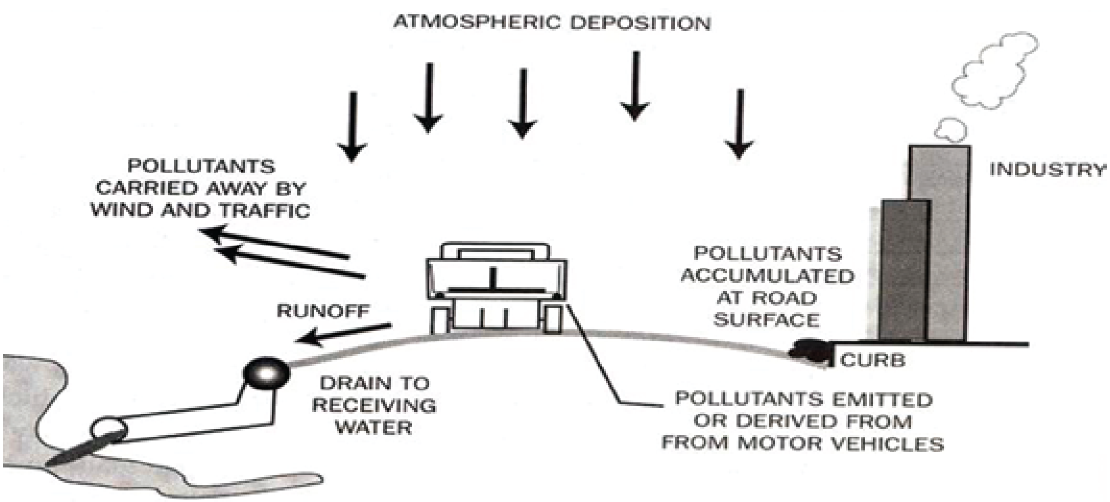

Figure 6-1. Pollutant accumulation on impervious street and highway surfaces. Source: Lehner et al. 1999.

	Resulting Impacts				
Increased Imperviousness Leads to:	Flooding	Habitat Loss	Erosion	Channel Widening	Streambed Alteration
Increased Volume	●	●	●	●	●
Increased Peak Flow	●	●	●	●	●
Increased Peak Flow Duration	●	●	●	●	●
Increased Stream Temperature		●			
Decreased Base Flow		●			
Changes in Sediment Loadings	●	●	●	●	●

Figure 6-2. Impacts from increases in impervious surfaces. Source: Lehner et al. 1999.

garden purposes and has negative implications for fish and wildlife.

Annually, degradation from urban stormwater pollution results in millions of dollars lost through government expenditures, illness, or loss of economic output. Furthermore, damage to the environment is as least as significant as that of the economy and would most likely be double or triple that amount. Figure 6-2 illustrates some of the environmental impacts that can occur from increased imperviousness. For example, increased imperviousness can lead to increased water volume which ultimately results in such environmental disasters as flooding, habitat loss, erosion, channel widening, and streambed alteration (Figure 6-2).

Stormwater Management Strategies

Until recently, stormwater management most often took the form of flood control and runoff evacuation in an attempt to avoid causing as much damage as possible. In recent years, however, communities have begun using proactive approaches to prevent, control, and treat urban stormwater pollution and have had great success in demonstrating the effectiveness, economic advantages, and benefits of these approaches.

Although controlling and preventing urban stormwater pollution sometimes requires the use of structural controls like subsurface storm sewer systems, many communities have succeeded in controlling stormwater pollution with natural resource-based planning methods like land preservation, strategic land use planning and protection, public education, addressing municipal operations, creation of wetlands or ponds, infiltration systems at parking lots, or incentives for compliance. The needs and resources of communities will vary, but any of these approaches to stormwater pollution control and prevention can be implemented with a little ingenuity, hard work, and a small amount of cash-flow. Additionally, many of these methods are superior to structural methods because they naturally clean runoff and reduce or avoid significant operation and maintenance costs, and, in some cases, provide recreational opportunities, wildlife refuges, and increased property values.

The best way to ensure that natural resource-based planning is incorporated into a community's stormwater management plan is through establishment of plan requirements. Stormwater management plans that retain the natural landscape (Chapters 2 and 3), put development in context of local and regional watersheds (Chapters 4 and 5), encourage riparian buffers (Chapter 4), reduce impervious cover (Chapter 6), and emphasize on-site, natural drainage of stormwater through the use of trees (Chapters 1,5, and 6) will make the most of a community's natural resources.

Reduction of Impervious Cover

During development of site plans, a key objective should be the reduction of impervious cover because increases in impervious cover can increase peak discharge as well as overall discharge rate over time (Figure 6-3). A wide range of site planning tools to reduce impervious cover are outlined in Appendix E. Although full utilization of these tools may be hampered due to existing local zoning regulations or subdivision codes, many can be creatively adapted to fit any situation and lead to narrower streets, green parking lots, and clustered subdivisions.

Limitations on Erosion During Development

When vegetation is cleared and a site is graded for future development, the impacts to urban streams can be particularly severe because trees and topsoil are removed, soils exposed to erosion, steep slopes cut, natural topography and drainage altered, and sensitive areas often disturbed. These destructive processes can be mitigated through the use of clearing restrictions, erosion prevention, and sediment controls.

Maintenance of Stream Protection Measures

If the desired level of stream protection is to be maintained over many decades, a concerted effort to inspect, maintain, and restore stream protection measures (e.g., riparian buffers and filter strips) that have been put in place must be made. Ideally, maintenance of many stream protection measures can be accomplished through public outreach efforts to educate residents on how they can prevent pollution in the watershed and periodically monitor stream quality.

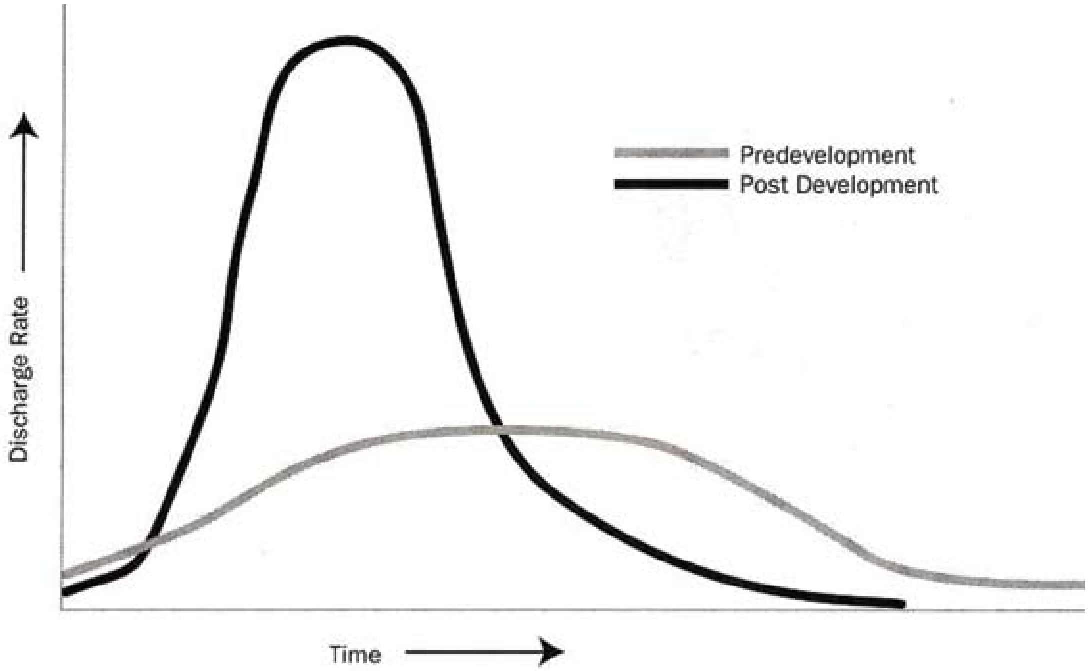

Figure 6-3. Pre and post development hydraulics. Source: Lehner et al. 1999.

Treatment of Stormwater Runoff

On a well-planned, properly designed site, the installation of urban stormwater BMPs to treat the quantity and quality of stormwater runoff can partially mitigate the impacts of development on urban streams. Such BMPs include ponds, wetlands, filters, and infiltration systems designed to replicate predevelopment hydrology and water quality. Some guidelines for stormwater BMPs include: encouraging natural and vegetated stormwater controls; ensuring maintenance of roads, lots, catch basins, and structural BMPs; supporting restoration where effective; and encouraging redevelopment and infilling to avoid further sprawl.

Wherever possible, trees should be incorporated to assist with other natural and structural stormwater controls. By working in combination with these other controls, trees can provide a comprehensive solution to rainfall interception, runoff, and landscape water use. Backyard cisterns can capture roof runoff and provide supplemental irrigation. Swales can help to hold stormwater overflow. Lawn-area retention basins can facilitate infiltration, and grates or drywells can capture driveway runoff.

Further strategies to enhance and incorporate the urban forest into control and treatment of stormwater runoff include:

- planting more trees in appropriate places,
- improving maintenance of existing trees,
- planting species with a higher rate of growth, where appropriate,
- planting species with architectural features that maximize interception,
- matching species to rainfall patterns,
- planting trees in groves, where possible,
- planting low water-use species,
- planting broadleaf evergreens where appropriate and avoiding south-facing windows, and
- using native plants, which, once established can easily withstand summer dry seasons and reduce the need for supplemental irrigation.

Goals and Recommended Actions for Urban and Community Stormwater Programs

When planning, implementing, or improving urban and community stormwater programs, communities should consider the following goals or recommended actions:

- **Plan in advance and set clear goals**. Programs should be carefully planned rather than reacting to opportunities, crises, or pressure. Careful planning allows development of more efficient and cost-effective actions and guarantees that issues and concerns of all stakeholders are addressed.
- **Encourage and facilitate broad participation**. Multiple levels of government, key community members, and professionals from a variety of related disciplines should be included in the planning and development process. All stakeholders should be included in overall growth plans, individual site development, educational efforts, and construction programs.
- **Work to prevent pollution first; rely on structural treatment only when necessary.** Focus should be placed in prevention-based approaches like regional and watershed planning, local zoning ordinances, preservation of natural areas, stormwater-sensitive site design, widespread compliance with dumping and connection prohibitions, erosion prevention, and broad-based education. Native trees and vegetation should be incorporated instead of, or in addition to, structural treatments. Utilizing trees' natural abilities to remove pollutants, and intercept and store stormwater is an environmentally friendly and economically sound alternative.
- **Establish and maintain accountability.** All parties need a clear statement of their performance standards and need to be held accountable by all the others to accomplish it. Local officials should set clear standards and incentives, conduct routine monitoring, promote public availability of stormwater runoff plans and permits, and enforce

laws and regulations in a firm and consistent fashion.

- ≈ **Create a dedicated funding source.** Funding stability is critical to program success and community support. Stormwater fees as well as stormwater utilities are good solutions to funding dilemmas.
- ≈ **Tailor strategies to the region and setting.** Municipalities should consider strategies that are particularly tailored to the region, the specific audience, and the problem, remembering that, while the basic framework of effective strategies may work anywhere, different locales may also require different solutions.
- ≈ **Build broad-based programs.** Effective stormwater programs should include and encourage planning, education, public participation, regulation, monitoring, and enforcement. The program's success may hinge upon the public's understanding of the issue, how it relates to them, and what they can do about it. Additionally, public-public and private-public collaborative opportunities should be investigated.
- ≈ **Evaluate and allow for the evolution of programs.** Programs should be based upon clear goals and priorities but be flexible enough to evolve as new issues arise, new technologies and strategies are developed, and the community or watershed changes.
- ≈ **Recognize the importance of associated community benefits.** Communities and local officials should recognize that stormwater runoff pollution prevention measures offer direct and indirect quality-of-life benefits.

The key goals above, when considered collectively, will build a strong framework for effective, efficient, and successful long-term stormwater runoff management.

Specific Strategies for Stormwater Runoff Management

Most stormwater runoff management strategies can be addressed by one of five broad project types: addressing stormwater in new development and redevelopment, promoting public education and participation, controlling construction site runoff, detecting and eliminating improper or illegal connections and discharges, or implementing pollution prevention for municipal operations. Strategies for each project type will be discussed below.

Addressing Stormwater Runoff in New Development and Redevelopment

Land use and development represents the most important category of stormwater runoff strategies because it encompasses a wide range of measures, from regional planning to the use of site-specific structural and nonstructural measures. These measures are most applicable in areas of new development or redevelopment; other elements of stormwater runoff treatment programs will need to be used in developed

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areas. However, one of the most beneficial characteristics of land use and development measures is that they can be applied area-wide or site-specifically using the appropriate BMPs.

Area-Wide Measures

Comprehensive non-structural runoff control strategies and area-wide planning are critical to the prevention of adverse environmental and economic impacts associated with urbanization because they protect the natural stormwater system, minimize the creation of impervious surfaces, and minimize the generation of pollutants.

Many states have enacted growth management regimes in an effort to reduce the amount of new development and associated impervious cover. Alternatives to automobile transportation such as bicycle routes and paths, mass transit, and car pooling can reduce impervious cover as well as pollutant discharge. Concentrating development near transportation and commercial services reduces vehicle miles traveled and associated infrastructure amounts. There are also noticeable reductions in air and water pollution.

Watershed planning allows municipalities to determine what land uses are consistent with desired conditions in water bodies and helps create ordinances that designate new development and land use changes to appropriate levels, types, and locations for water bodies of concern.

Under performance zoning, uses for parcels of land are not specified. Instead, performance standards are set for open space preservation, impervious surface area, maximum pollutant emissions, or other criteria the municipality deems important. These approaches help preserve or enhance the desired character of a community and protect natural resources that are important to residents and can reduce the cost of providing community services such as public safety, water and sewer service, and roads.

Reuse and renovation of existing commercial buildings or industrial sites provides an opportunity for economic development with little or no addition of impervious cover, allows business and citizens to take advantage of existing municipal infrastructure, reduces pressure to develop current natural areas, and revives urban neighborhoods.

Site Design Measures

Minimizing imperviousness on a site is more prevention-focused and cost-effective than treating stormwater runoff and also much more cost-effective than restoring water bodies after pollution or damage has occurred.

Conservation-design development seeks to cluster or concentrate homes on a small percentage of land comprising a subdivision and leaves the rest of the land as open space. Consequently, the amount of impervious road surface created is reduced and a much greater percentage of undeveloped land is preserved.

Developers in commercial and municipal sites have also implemented alternative parking arrangements such as lot sharing, planning for average parking demands, placing parking areas between commercial buildings, and constructing multistory parking garages to minimize imperviousness.

Another technique to reduce overall imperviousness is the use of porous pavement which allows water to pass through it into the soil while retaining enough strength to support vehicular traffic. Porous pavement is typically used in the construction of parking lots as a built-in stormwater treatment device and can also be modified to accept runoff from surrounding areas and rooftops.

Another, more comprehensive approach to site-specific planning is the traditional neighborhood development (TND). Like conservation-design developments, TNDs seek to minimize impervious cover in the built environment and preserve open space through compact development patterns that feature narrower roads, shared alleyways, smaller lots, and smaller street front setbacks. However, TNDs also incorporate mixed-use development by providing stores, offices, schools, day-care centers, recreational opportunities, and mass-transit facilities within a short walk of residents' homes, thereby providing the option of walking rather than driving.

Site-Specific/Structural Runoff Control and Treatment Best Management Practices

While the management measures mentioned above are the most efficient and cost-effective methods of stormwater runoff pollution prevention, these measures may not always be adequate to deal with stormwater runoff problems caused by new development or redevelopment. In such cases, it may be necessary for municipalities to resort to site-specific runoff control and treatment through structures engineered to remove contaminants from runoff and control its flow. Such so-called "structural" management measures include detention practices, biofiltration and bioretention practices, infiltration practices, filtration practices, and natural drainage systems. A list of other structural and non-structural BMPs is included in Appendix E.

Detention Practices

Detention practices temporarily store stormwater runoff and discharge it through an outlet structure into water bodies. Typically, detention practices are accomplished through wet or dry detention ponds. In dry detention ponds, all water is released within a designated time period. In wet detention ponds, water is retained for longer periods of time and may remain permanently. Subsequently, wet detention ponds can be both aesthetically and recreationally appealing (Figure 6-4).

Fundamentally, detention ponds are created to reduce peak flows, thereby improving water quality and allowing settling of sediments and other contaminants. Additionally, since wet detention ponds retain water longer and often contain aquatic flora and fauna, they can aid in biofiltration practices.

Biofiltration and Bioretention Practices

Biofiltration and bioretention practices use plants to filter stormwater and reduce contaminant loadings. The benefits of using plants as an additional filter medium are two-fold: absorption of nutrients and metals and slowing of stormwater flow. Bioretention areas likewise capture runoff and allow slow infiltration, enhancing pollutant removal and water cooling.

Communities and municipalities wishing to control stormwater use such types of biofiltra-

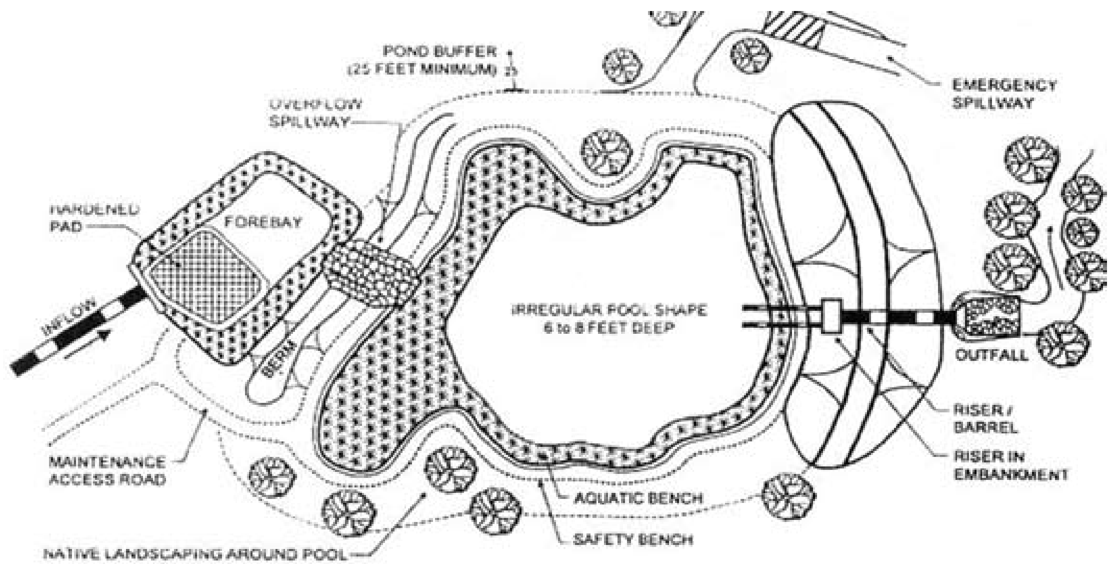

Figure 6-4. Example of a wet detention pond. Source: Center for Watershed Protection 1998.

tion as constructed wetlands, engineered filter strips, and swales. All of these biofiltration methods share the use of native vegetation (i.e., reeds, wetland plants, grasses, trees, shrubs, and vines) to filter stormwater as it flows across or through structures.

Infiltration Practices

Infiltration practices reduce peak flows by using basins to temporarily store runoff and allow slow water percolation into the soil. In fact, correctly installed and designed and regularly maintained infiltration practices closely resemble the natural process of infiltration that occurred prior to the increase of impervious cover, and are among the most effective structural BMPs.

Natural Drainage Systems

One specific approach to site-specific, natural stormwater control is through the use of natural drainage systems (NDS). NDS, as an alternative to traditional drainage systems, provides higher levels of environmental protection for receiving waters at a lower cost. In NDS projects, natural features such as open, vegetated swales, stormwater cascades, and small wetland ponds are incorporated to mimic natural functions lost to urbanization (i.e., infiltration, pollutant removal, and aesthetics). Additionally, NDS provides a number of benefits over traditional drainage systems, including easier integration into the landscape; more natural appearance than engineered systems; elimination of the need for more costly conveyance systems, detention facilities, and mitigation; and impervi-

Figure 6-5. Example of street without natural drainage systems (left) and with natural drainage systems. City of Seattle 2004.

ous surface reduction. Figure 6-5 illustrates the difference between a street with and without NDS.

Because street right of ways are frequently underutilized functionally and aesthetically, they represent particularly appropriate targets for NDS. In fact, applying NDS design alternatives can help communities reach:

- ≈ drainage goals,
  - meet detention requirements/goals, and
  - meet water quality requirements;
- ≈ pedestrian and emergency vehicle safety and access,
  - provide porous sidewalks,
  - allow safe pedestrian access from car to sidewalk, and
  - allow emergency vehicle access through neighborhood;
- ≈ biological goals,
  - optimize use of space so trees can be planted,
  - promote healthy tree and vegetation root growth,
  - reduce competition between roots and pipes, and
  - use right-of-way area as public open space amenity;
- ≈ maintenance goals,
  - inspire neighborhood participation, and
  - provide easy access to infrastructure; and
- ≈ financial goals,
  - lower or neutral in cost than traditional drainage systems.

Natural Drainage System Design Alternatives

Numerous environmentally sound and economically viable design alternatives are available for use within street right-of-ways. Each alternative will have different capabilities of conveying stormwater. Discussed below are several alternatives, in order of increasing capability to convey stormwater.

Tree Retention

Retaining trees all ready in place on a site helps avoid the costs of removing the tree, establishing and maintaining a younger tree, and capitalizes on the natural drainage abilities of the tree. Designing around these trees allows the interception and evapotranspiration capabilities of the site to be maintained.

Tree Pit Enhancement

Where problems with ponding on sidewalks exist, tree pit areas should be widened. Exposing a larger soil area allows greater infiltration, reduces water problems, and increases water for vegetation. In addition, larger tree pits create the opportunity for planting native flowers, shrubs, or vines, which can enhance the aesthetics of the right-of-way.

Infiltration and Conveyance Trench

Even traditional infiltration trenches spaced in planting strips can be adapted to better convey and absorb water. A meandering trench within the planting strip allows exposed gravel to be arranged in a more aesthetically pleasing manner. Infiltration and conveyance trenches with planting strips ≥8 feet with a slope of 1 to 6%, and a rock trench 2 to 3 feet wide and 2 to 3 inches deep can adequately drain an adjacent sidewalk or sidewalk plus road. Sizing and rock type will vary according to goal.

Linear Bioretention Systems

When stormwater runoff enters a planting strip, it passes through the mulch or gravel layer, infiltrates into and filters through the soil, and steadily moves down gradient along the length of the strip. The filtered runoff is then conveyed through an exit pipe to the main stormwater system. The use of amended soil in these planting strips promotes vegetative health, runoff infiltration, and water quality. Experimental amended soil mixes with predominantly sandy soil and enough planting soils and compost to sustain vegetation growth have been successful in Seattle, Washington and would be applicable in other parts of the U.S. Linear bioretention systems with a planting strip 4 to 5 feet wide, a soil depth of 2 to 3 feet, a ponded water depth of 1 to 6 inches, and a slope of 1 to 6% will adequately drain an adjacent sidewalk or sidewalk plus road. Sites exceeding 4% slope will require check dams, and larger, steeper drainage areas will likely require surface treatment with gravel instead of mulch. Sizing varies according to goal.

Subsurface Linear Bioretention System

In ultra-urban environments, where space for trees and other vegetation and their roots is minimal, at best, adapted linear bioretention systems can be used. Methods of employing the systems include concrete tree boxes with or without interconnection to other tree boxes, continuous concrete trench boxes with grate tops, or structural soil mixes. Stormwater surface flow enters the systems through curb openings and catch basins.

Porous Pavement

Another method of addressing stormwater flows is through the use of porous pavement. Porous pavement reduces the amount of surface flow generated and encourages infiltration by allowing the water to flow through into the pavement's subbase. The subbase provides detention while water infiltrates into native soil, is filtered, and later discharged through an outlet. Porous pavement can be used over a large surface area with a linear slope of 0 to 5% to adequately drain adjacent street, sidewalk, and rooftop areas. Pavement surface area will vary according to needs and goals.

Interconnected Vegetated Swales

Interconnected vegetated swales are modified standard bioswales, the simplest of which is a gradually sloped vegetated ditch connected with culverts under driveways (Figure 6-6). The swales are used to store water volumes generated by adjacent streets and rooftops and achieve overall water quality improvement. Detention swales can be created in several ways, including using undersized culverts to connect the swales so that flow is forced to backup during large storm events and using flow control

Figure 6-6. Example of interconnected vegetated swale. City of Seattle 2004.

structures to back flow into the detention areas.

Swale sizing varies according to goal, drainage area, and site slope. Minimum top swale width is ~9 feet; minimum length of swale area is 200 feet, while maximum surface ponding depth is 1 foot. Detention capacity for the swales is ~2 acres, while conveyance capacity is ~10 acres. Swales are best used in pervious right-of-ways with a width ≥11 feet and a linear slope of 2 to 6%. Sites exceeding 4% slope will require check dams and/or surface treatment with gravel instead of mulch.

Rock and Vegetation Systems

Velocities of surface flow during storm events can often exceed the infiltration and detention capabilities of standard vegetated practices. When large drainage areas are confined to proportionately small, inadequate conveyance channels, velocities become too high to be controlled. To better convey these flows through vegetated surfaces, channel areas can be armored with rocks or geotextile fabrics and divided by check dams along their entire length.

Due to the large drainage areas of these systems, detaining and treating the full volume of a storm event is not possible without subsurface detention pipes. However, detention and treatment is possible for a portion of the drainage area if cells are designed to maximize available space. Minimum top width is ~10 feet; minimum length is ~200 feet. Maximum surface ponding depth of 1 foot is recommended. Pervious right-of-ways ≥15 feet, with a linear slope of 2 to 10% can drain an area of 10 to 35 acres.

It is important to remember that any measure taken to treat or control stormwater runoff must be carefully selected, evaluated, monitored, and maintained to be effective. Some measures will not be appropriate for all areas, soil types, or water tables, and, if applied incorrectly, can cause such problems as pollutant concentration, adverse mineral transformation, reduced effectiveness over time, increased water temperatures, and loss of fish and other aquatic organisms. To avoid these and other problems, it is best to use a combination of BMPs to insure broader treatment, improved effectiveness, and avoid undesirable side effects. All of the above stormwater design options are presented as general information and guidelines. Any application of specific stormwater controls should be designed, installed, and maintained by a professional.

Although post-construction measures and activities like those mentioned above (planning, site design, and structures) represent the most extensive stormwater control measures, the most successful stormwater programs also incorporate public education, construction site controls, elimination of illicit discharges, and improved municipal practices.

Promoting Public Education and Participation

If local governments hope to have a successful stormwater pollution control program, they need, and can get, broader community support. Through day-to-day activities and support for municipal programs and ordinances, individuals can play a key role in reducing stormwater impacts. In fact, many case studies suggest that the effectiveness of BMPs in other programs is directly tied to the effectiveness of public education programs.

The link between local governments and its citizens is formed by public education, outreach, and participation. Citizens can be encouraged to change their habits and routines in activities such as lawn care, car maintenance, pet walking, and other cooperative efforts. These grass-roots efforts often lay the groundwork for broad-scale municipal stormwater programs.

In previous years throughout the United States, public education programs have been successful in addressing a wide range of activities. Programs can encourage citizens and businesses to reduce chemical pesticide and fertilizer use, switch to natural pesticides and fertilizers, practice alternative landscaping with native plants, and embrace integrated pest management with pest-resistant plants, pest level monitoring, realistic pest tolerance levels, and reliance on alternative pest management strategies. All of these practices, as well as many others, minimize the quantity and toxicity of pesticides used, thus reducing the toxicity of runoff.

Another outlet for public education is through promoting participation in civic stormwater control activities and water quality control monitoring. Neighborhood groups can paint stencils or post signs near storm drains with messages like "Don't Dump; Drains to Bay" or "Dump No Waste; Drains to Stream" (Figure 6-7). Citizens can take this one step further by helping to monitor water quality in local water bodies, inventory and sample stormwater outfalls, and restore and repair damaged water bodies. The immediate environmental results following these activities provide tangible evidence of the importance and necessity of each individual's contribution to the project and have proven to be very successful and attractive to the public. However, the key to the success and effectiveness of any education program is distinguishing among different audiences (i.e., school children, homeowners, business operators, or outdoor recreationists) and providing information directed specifically to them. In this manner, it is possible to focus education efforts and materials on specific sectors of the community or, alternatively, on pollution problems specific to a sector.

Local governments use a variety of public education and outreach activities. They can be as passive as radio and television advertisements, newsletters, brochures, Web sites, toll-free telephone lines, or as active as games, educational activities, and in-school programs for children, workshops and presentations for business and community groups, or tours of areas affected by stormwater pollution. Additionally, local governments can actively seek and encourage participation in public hearings regarding stormwater management ordinances and programs, growth management regimes, approval for highway or residential development projects, public transit planning and budgeting, and other government activities affecting stormwater pollution. Local governments can also encourage public education through mentoring, where experienced volunteers assist newcomers in learning environmentally beneficial practices.

Finally, success in education/outreach programs can be achieved if three goals are accomplished: educate the public about the nature of the urban stormwater pollution problem—its causes and consequences, inform the public about what they can do to solve the problem, and, ultimately, through hands-on education, achieve pollution reduction or restoration targets.

Figure 6-7. Example stencils for programs to reduce stormwater pollution. Designs courtesy of A.L. Husak.

Controlling Construction Site Runoff

Although only one of a number of industries with stormwater impacts, construction impacts are so significant that they are treated separately under federal, state, and local programs. In fact, short-term construction projects can produce as much stormwater pollution as years of other activities. Results from both field studies and erosion models indicate that erosion rates from construction sites are typically an order of magnitude larger than row crops and several orders of magnitude greater than rates from well-vegetated areas, such as forest or pastures. Fortunately, effective construction pollution prevention is politically and economically feasible, can dramatically reduce stormwater pollution, and is beneficial to the developer through increased property values.

Local construction site stormwater management strategies aim to effectively reduce runoff volume to levels that will not cause erosion and to capture as much as possible of the sediment and other pollutants. The most effective local programs rest on four cornerstones: education and training, enforcement, erosion prevention, and sediment control.

Measurable stormwater pollution reduction from construction activities can be achieved

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through education and enforcement. Successful education programs include essential elements like close cooperation with both local developers and citizen groups, a variety of outreach and communication modes, and clarity in communicating both regulations and technical methods. Key elements of education and training programs include:

≈ publishing a brochure, booklet, and/or manual explaining all locally applicable requirements and to the extent possible, consolidating requirements and permits for one-stop permitting,
≈ holding training workshops for contractors and inviting the public to them as well,
≈ certifying those who pass a test following a comprehensive training workshop,
≈ holding pre-construction meetings and on-site walk-throughs prior to initial site work and adjusting the erosion and sediment control (ESC) plan at the construction site, and
≈ inspecting sites after storms and assessing ESC practices.

No education or training program can be complete or successful without an accompanying method to enforce the regulations and guidelines set forth. Successful enforcement programs include such key elements as:

≈ supporting county or regional-level enforcement authorities, thus cutting your own costs,
≈ staffing, legally empowering, funding, training, and certifying an adequately sized team to enforce requirements and inspect sites,
≈ partnering with citizens and conscientious developers and contractors to watch sites and report violations,
≈ publicizing enforcement actions,
≈ requiring developers to post bonds against potential damages, and
≈ requiring regular maintenance of BMPs, including dredge-out of sediment basins.

Common erosion prevention techniques use site planning and construction phasing to minimize unregulated areas exposed at any one time and shelter graded or denuded soil from rain and snow melt. In fact, a 1997 national survey found erosion prevention practices (site design, planning, and phasing) are commonly capable of reducing 90% of suspended solids leaving a construction site. Key elements of successful erosion prevention programs include:

≈ minimizing needless clearing and grading using site planning, open space, buffer zones, and other protections,
≈ protecting waterways and stabilizing drainage ways,
≈ phasing construction to reduce soil exposure,
≈ immediately covering, revegetating, and stabilizing exposed soils with mulch or other means; at most, using a 14-day limit,
≈ prohibiting clearing and grading of steep slopes, and
≈ employing additional measures for sen-

sitive areas such as buffer zones around wetlands, and special protections and prohibitions depending upon slope steepness.

Sediment controls attempt to capture sediment after it has eroded off a hillside or graded area. Key elements of sediment control programs include:

- ≈ installing controls to filter sediments, including exit controls, and inlet filters at the site perimeter and, on larger sites, throughout the site, and
- ≈ employing advanced sediment settling controls, like well-designed and maintained basins.

Incorporating most or all of the above education and training, enforcement, erosion prevention, and sediment control elements will help guarantee the success of stormwater pollution prevention programs.

Detecting and Eliminating Improper or Illegal Connections and Discharges

Identifying and eliminating illicit connections and discharges is one of the simplest and most cost-effective ways for local governments to eliminate some of the worst pollution from stormwater and improve water quality. Two factors are critical to the success of this element of stormwater programs: tracking or finding illicit connections and discharges and enforcement. Routine inspections or system surveys help prevent illicit connections and discharges, and enforcement makes certain that problems are dealt with quickly and appropriately.

Stormwater pollution can occur through intentional activities like dumping waste oil into storm drains or routing wastewater lines to storm sewer systems, but can also occur through simple negligence. Materials stored outside, and oil and chemicals dumped on the ground, are picked up by stormwater and transported to receiving waters. Other occurrences like septic system overflow, sanitary sewer line leaks, car washing, mobile pressure washing, draining swimming pools, and irrigating lawns and gardens likewise discharge pollutants into storm sewers and degrade water quality.

Finding illegal discharges and illicit connections often requires the use of a range of techniques. Municipalities inspect septic systems to confirm they are well-maintained and large enough; landfills; service stations; industrial and commercial sites to make sure pollutants are removed or properly stored; and sanitary sewer systems for leaks and overflows. Additionally, 24-hour hotlines, utility bill fliers, and other educational efforts can help municipalities get the public involved in identifying and reporting illicit discharges and connections.

Finally, effective programs include enforcement such as fines and citations to punish illicit dumping of waste and expedite removal of illicit connections to storm sewers. Municipalities that use enforcement efforts such as these often receive much-needed community support and experience greater motivation to pay attention to education efforts regarding stormwater pollution.

Megan Bean, MSU

Implementing Pollution Prevention for Municipal Operations

Many operations undertaken by municipalities can affect stormwater quantity and quality. Consequently, local governments should make a concerted effort to manage municipal operations to make a significant positive contribution to reducing stormwater pollution (as mandated by the federal governments Clean Water Act Phases I & II and to reduce or eliminate stiff non-compliance penalties). Successful strategies can incorporate municipal activity areas to curb stormwater pollution in a variety of ways, including:

- ≈ using, improving, or expanding municipal services provided for other purposes, like street sweeping, leaf and yard waste collection, oil collection and recycling, and trash control;
- ≈ enacting frequent and thorough maintenance on municipal vehicles to reduce oil, grease, and metals left on roads and parking lots;
- ≈ converting to low-emission or zero-emission vehicles powered by natural gas, electricity, or other alternative energy sources;
- ≈ reducing application of pesticides and fertilizers, especially on trees and turf areas, in parks, cemeteries, and high-

way rights-of-way;

- ≈ employing sound landscaping practices such as planting native species and using integrated pest management;
- ≈ monitoring and reducing salt and sand application on icy roads;
- ≈ incorporating stormwater control requirements in all construction contracts;
- ≈ properly maintaining structural and nonstructural runoff and erosion control devices;
- ≈ targeting training and education efforts for every audience (i.e., officials, decision makers, builders/developers, agency personnel, park and utility workers, fleet workers, construction workers, public citizens); and
- ≈ conducting periodic environmental audits.

Megan Bean, MSU

Chapter 7: Guidelines for Addressing Natural Disturbances

Environmental impacts resulting from natural disturbances are of increasing concern to urban forest managers and the communities they serve. Hurricanes, tornadoes, floods, ice storms, and wildfires receive much attention due to their sudden and often catastrophic effects. Other natural disasters such as drought and pest invasions may occur more slowly over time, but can be equally devastating with chronic, lingering effects. Regardless of the type of natural event, preparation for the inevitable is essential in developing a readiness and response strategy that minimizes the initial damage, and facilitates a more effective and sustainable recovery.

Storms Over the Urban Forest

Hurricanes

A hurricane is defined as a strong tropical storm created over warm ocean waters by a low-pressure system, with organized convection and a counterclockwise surface wind circulation. A single storm may stretch more than 300 miles wide, and generate destructive winds

NASA

along coastlines for several hours to several days. Hurricanes are commonly accompanied by heavy rainfall and tornadoes that result in localized flooding and wind damage to trees further inland.

The National Weather Service measures storm strength according to wind speeds recorded at one-minute intervals, in addition to stormwater surge levels that may range from 4 to 18 feet above normal. Storm data collected by the National Oceanographic and Atmospheric Association (NOAA) is based upon the Saffir-Simpson scale, which ranks storms on a five-point scale from Category 1 (74 - 95 mph) up to Category 5 (in excess of 155 mph). Detailed hurricane weather data is available from the NOAA Web site at www.weather.gov.

Hurricanes are no surprise to residents of the Mississippi Gulf Coast, who have experienced five major storms since the infamous Category 5 Hurricane Camille in 1969. Hurricane Katrina became one of the most devastating storms on record in August 2005, making landfall as a Category 3 storm with sustained winds in excess of 120 mph and a storm surge over 28-feet deep. Salt water surges near Biloxi traveled for more than a half-mile inland, uprooting trees and wreaking havoc on homes and beaches. Initial estimates placed the total economic damage at greater than $81 billion, with a long-term urban environmental impact that is still yet to be determined.

An inventory of 181 cities and communities reported that over 2.7 million trees were afflicted during Hurricane Katrina, and nearly all of the urban forest along the Mississippi coastline was either damaged or destroyed. The southern half of the State was subjected to winds in excess of 75 mph, and more than 50% of the urban tree population from the coast inland was either destroyed or severely damaged. Economic damage to the urban forest alone was estimated at more than $1.1 billion, and additional damage to the state rural commercial timber stands pushed tree casualty losses to greater than $2.4 billion.

Both state and federal relief agencies concur that damage from hurricanes and other catastrophic forces of nature is often predictable but is rarely preventable. The arduous task for urban forest managers is to continue to develop better initiatives that more effectively mitigate these disasters before they happen and after they occur.

Site Adaptability and Storm Resistance

The majority of trees and vegetative under story able to withstand these types of catastrophic events are those genetically adapted to adverse weather conditions, possessing a multitude of characteristics that allow them to recover even under prolonged periods of climatic stress. The three critical attributes for survival include tolerance against:

1. wind strong enough to cause breakage and uprooting.
2. salt from ocean sprays and storm surges that cause defoliation and root burn.
3. soil moisture fluctuations caused by

prolonged flooding that lead to root suffocation.

Any of these factors may occur autonomously or in combination with other environmental conditions.

Soils within the coastal region are generally acidic with a pH below neutral, and a porosity ranging from excessively well-drained sands to poorly-drained clays. Trees planted in severely acidic soils may be subject to aluminum or manganese toxicity, and may experience elevated water tables measuring from surface level to greater than six feet deep. Air temperatures in the southeastern United States also vary from 15°F in winter to over 100°F in the peak of summer, and may fluctuate more than 50°F in a 24-hour period. Thus, correct plant selection is essential in terms of adaptability and survival.


Julie Jordan, MSU

Storm Resistant Species Selection

Selection of wind resistant vegetation may be the most important factor in hurricane mitigation planning, especially in an urban setting where trees are often initially damaged by construction and substandard maintenance practices. U.S. Forest Service studies describe storm resistant trees as those with a compact growth form and low center of gravity, with a naturally tapering trunk and a tap root complemented by well-developed secondary roots.

For hundreds of years the first line of natural defense for the Mississippi gulf coast has been the live oak (*Quercus virginiana*) shown to be the most wind tolerant of all native species. This tree is dominant from Texas through the Carolinas, and is indigenous from the beachfront to several miles inland. Live oak and its smaller cousin the sand oak (*Q. geminata*) rank among the highest for resistance to breakage and uprooting, and are also among the most salt tolerant of all species.

In addition to live oak, palm (*Sabal palmetto*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), and sycamore (*Platanus occidentalis*) rank the highest in salt resistance, along with baldcypress (*Taxodium distichum*), pondcypress (*Taxodium distichum nutans*), southern red oak (*Quercus falcata*), magnolia (*Magnolia grandiflora* and *virginiana*), and tupelo (*Nyssa spp.*). Salt can be deposited by a storm surge as well as in the form of salt spray carried by high winds. Salt crystals form on foliage and within the root zone as evaporation occurs, weakening and killing non-resistant plants through defoliation and severe root burn.

Tree leaves saturated with salt water turn brown and appear as if they were burned, and may defoliate partially or completely within a short period of time. Most trees will not die and should not be cut immediately, but instead evaluated at the onset of the following growing season to determine the extent of their recovery. Be aware that salt damaged trees commonly suffer a combination of stress factors from wind and flood injury, and may become subject to pest infestations that force their removal prematurely.

Baldcypress, tupelo, sweetbay magnolia (*Magnolia virginiana*), and willow (*Salix spp.*) rank highest for flood tolerance, along with sweetgum (*Liquidambar styraciflua*), river birch (*Betula nigra*), cottonwood (*Populus deltoides*), and green ash (*Fraxinus pennsylvanica*). These native species are naturally adapted to flood plains and bottomlands where they are frequently subjected to submersion for several days or even weeks. They make excellent candidates for replacement of less moisture tolerant species in areas prone to repeat flooding.

Conversely, trees adapted to mesic and upland sites like magnolia, hickory, maple, and cedar rank among the least storm resistant species. Other wind-prone species that possess a dense canopy and high center of gravity include pine, crape myrtle, and dogwood. Species with weak wood strength and poor branching habits such as Bradford pear and hackberry are also more vulnerable to breakage, and may subsequently become victims of disease or insect infestation. See Table D-9 in Appendix D for storm resistant trees recommended for the Southeast.

Pre-Storm Checklist for Existing Trees

Comprehensive assessment of the health and condition of urban trees is crucial in minimizing the initial environmental impacts of a major storm. The type and extent of pre-storm damage can help gauge a tree's potential for survival, and it is important to remember that older trees have more difficulty recovering from injury than younger specimens.

Broken limbs and split branches should be properly pruned and repaired in advance for safety reasons. Pruning cuts should be made smoothly just outside the branch collar. For detailed pruning illustrations visit the Mississippi

Forestry Commission Web site at www.mfc.state.ms.us. Pre-existing wounds should also be carefully inspected to determine the tree's internal integrity, and to check for secondary pest infestation.

Leaning or uprooted trees may be candidates for either uprighting or removal depending upon the extent of root damage. Installation of guy wires or stabilizing braces may be recommended on uprighted trees for a minimum of two years after repairs are made. Shallow rooted species should be pre-planted into groups to help reinforce one another.
Note: Trees greater than 4-inch caliper dbh pose a much greater hazard of uprooting in subsequent storms, and therefore should not be considered as viable candidates for uprighting.

Eroded or silted root zones should have the soil restored to its original level, with special care taken to protect living roots. Backfill firmly to the original soil line with existing parent soil if available (do not overfill), and apply up to three inches of pine straw mulch to maintain soil moisture and provide insulation against extreme temperatures.

Lightning damage may range from no visible signs to total tree destruction, with lone trees sited as the most vulnerable. Insurance companies should be promptly notified after a lightning strike occurs in the event that the tree dies (which may occur 12 months later). Fertilizer recommendations based on soil test results may be applied to aid in root rejuvenation, along with more frequent watering during dry periods on trees with limited damage.

Less cold hardy species-with a minimum temperature range of 25°F should be planted on the southern or eastern side of buildings, and covered if possible during prolonged periods of temperature below the mid-20's.

Hazard Tree Removal Decisions

Storm damaged trees pose varying degrees of danger to people and property based upon the initial amount of injury they receive, and their close proximity to high-traffic urban settings where they pose an immediate safety hazard. Large trees leaning against power lines or lodged on top of houses obviously require immediate attention, along with those blocking major roadways that interfere with emergency response vehicles. Other trees in a neighborhood may be just as severely damaged, but may pose no immediate threat if there is no "target" located nearby.

After all safety considerations have been addressed, the most difficult part of responding to storm damage is deciding which trees to prune and which ones to remove completely. These decisions should be made only by certified tree care professionals, who utilize a number of factors to determine which specimens should be cut down and which can be restored. Assessment of potentially hazardous trees should be based upon the following factors.

1. **Amount of damage**-a general rule of thumb is that a tree with more than 50% of its canopy physically broken is not worth the restoration effort. Trees that suffer defoliation or root damage from wind/salt/flood injury that do not regrow at least 2/3 of the canopy within the next growing season are also probably not worth saving.
2. **Tree size and age**-Younger trees generally survive wind injury better and can recover faster, making them more suitable candidates for restoration pruning. Larger trees of greater age are more likely to have accumulated multiple defects over time, and are much less likely to recover from serious physical damage.
3. **Tree species**-Those with inherently good compartmentalization ability (i.e. live oaks) are better able to resist the spread of decay into their wood, and are easier to restore. Short-lived species (less than 50 years) usually possess poor compartmentalizing qualities, and it is rarely economically feasible to restore them.
4. **Tree health**-Healthy trees naturally recover faster than those with pre-existing pest infestations. The presence of deadly decay fungi (i.e. Armillaria root rot) indicates that a tree's entire structural integrity may be compromised, prompting immediate removal.
5. **Tree structure**-One main trunk growing terminally up through the canopy, along with well-spaced lateral branches smaller than the trunk, and a balanced canopy are all signs of a strong tree. Codominant (twin) main stems, and tightly spaced vertical lateral branches promote the growth of bark inclusions, which can easily split apart in strong winds.

6. **Previous poor cultural practices**-Topping the canopy stimulates the growth of an excessive number of sprouts, resulting in weak wind-prone branches. Pruning extremely large limbs leaves large open wound sites that serve as entry points for decay fungi. Poor root management is another common cause of tree failure in the urban forest, due to cramped planting areas that are often sites for ongoing construction activities.
7. **Site conditions**-Soil compaction, shallow soils, hardpans, and a high water table can all result in weak root systems and unstable trees. Poor placement such as locating trees under power lines may cause them to be removed rather than restored.
8. **Cultural value**-The value of a tree to the individual and to the community will determine the level of restoration effort required. In addition to economic value, trees with the greatest historical or ecological significance typically will be given the highest consideration.

Urban Forests After the Storm

Assessing Hazard Trees

Many trees may have been weakened after a major storm, and could pose a hazard to public safety, infrastructure, or power supply. The Mississippi Forestry Commission recommends that every tree that has a potential target within a distance equal to its height be assessed.

If any one of the following danger signs is present, consult a professional forester, arborist, or tree surgeon immediately. Until a hazard tree is removed or repaired, stay clear and move assets that may be a target.

1. Broken limbs over three inches in diam-

FEMA/Mark Wolfe

eter lodged or hanging in the crown.

2. Broken top or broken fork that has impacted more than 25% of the original crown.
3. New cracks in the main trunk.
4. Raised soil or exposed root crown.

Disposing of Debris

Downed trees and woody debris should be transported to the public right-of-way as soon as possible. Logs should be left in the longest length that can be transported to the road and separated for salvage operations. Woody debris should be kept separated from construction materials and food products for safety reasons.

Be aware that hazardous fuel conditions could exist due to extensive storm damage. Do not burn debris, as some materials may be toxic, and also consider that burning may ignite wildfires.

Hiring a Tree Service

Check the phone book for local listings of licensed tree services and arborists. Other resources include the city arborist, Mississippi Forestry Commission, Bureau of Plant Industry, or County Extension Service office.

It is essential to verify that the company doing the work is fully insured and bonded for property damage, personal liability, and workers compensation. Be sure to obtain a copy of these certificates, and before proceeding verify that the insurance company policy is current. Request and check references from recent clients, and try to get more than one written estimate for the work being done.

Never hire a company that recommends topping of trees, and be wary of an arborist that wants to do extensive work on living trees that appear to have limited damage. If a tree removal is deemed necessary, obtain a written quoted agreement covering the complete removal of the limbs, debris, and stump, including cleanup.

Do not pay in advance, only after the job has been completed to full satisfaction. Be cautious about dealing with companies from out-of-state, or those offering upfront discounts. Also realize that trees have commercial value in the form of firewood, saw logs, or chips, and that the value should be considered in the estimate.

Chainsaw Safety

Only trained and experienced operators with proper safety equipment should attempt to use chainsaws during storm debris cleanup. However, many homeowners will still attempt to perform the work themselves rather than hiring a professional tree service, and should pay special attention to the following safety guidelines. Be aware of the many hazards that exist, including:

1. overhead broken limbs and tops
2. power lines
3. limbs and trunks under pressure
4. stepping obstacles
5. construction debris

Trees on the ground present many hazards

similar to standing trees, and should be handled just as cautiously. A thorough assessment of every tree should be made prior to cutting, to evaluate the potential risks before determining what and where to cut.

Follow all manufacturer safety guidelines when handling any type of wood cutting equipment. Always wear proper protective clothing recommended for the job, which may include steel-toed leather boots with non-slip soles, long-sleeved shirt and long pants, saw-proof chaps, leather gloves, hardhat, and eye and hearing protection.

Additional protective equipment may be recommended by a product manufacturer, and should be worn accordingly. Check the owner's manual for additional information on safety and equipment operation, and keep a record of manufacturer's contact numbers and website information.

When cutting, always be aware of the location of the tip of the bar to avoid the hazard of potential kickbacks. Never run a chainsaw when safety features are not in place or are non-operational, and never run a saw when tired or impaired. When unsure of what will happen if a cut is made, stop and seek expert assistance.

Pruning

The benefits of pruning must outweigh the negative impact of creating wounds along branches and the main trunk. Remember that trees do not actually heal, but rather seal off wounds by a process known as "compartmentalization."

Limbs pruned at the correct location and in the proper manner will likely seal more successfully than those that are pruned improperly. Trees are naturally able to seal off most pruning cuts with sap and with new wood over time, and it is therefore recommended to avoid the use of pruning paint or other artificial covering to protect a wound after pruning. Limbs that are less than three inches in diameter and are within reach of the ground may be pruned with loppers or a saw. Larger and higher limbs should be removed by a professional with appropriate equipment and insurance.

Basic rules for pruning include the following considerations.

1. Select limbs for removal that insure optimum safety and maintain the structural integrity of the tree.
2. Remove dead or diseased branches first, and avoid making stub cuts if possible.
3. Prune to maintain the correct shape and balance of the tree.
4. Remove no more than 25% of the entire canopy during one year.
5. Take special care to remove branches at a node, making the pruning cuts just outside the branch collar while avoiding the bark ridge.

Tornadoes

A tornado is defined as a violently rotating column of air that is in contact with both the surface of the earth and a cumulonimbus or a cumulus cloud. A tornado is typically formed in the shape of a visible condensation funnel which is wider toward the top, with the lower end often encircled by a cloud of debris near the earth's surface.

Tornadoes have been observed on every continent except Antarctica, and occur most frequently within the United States which

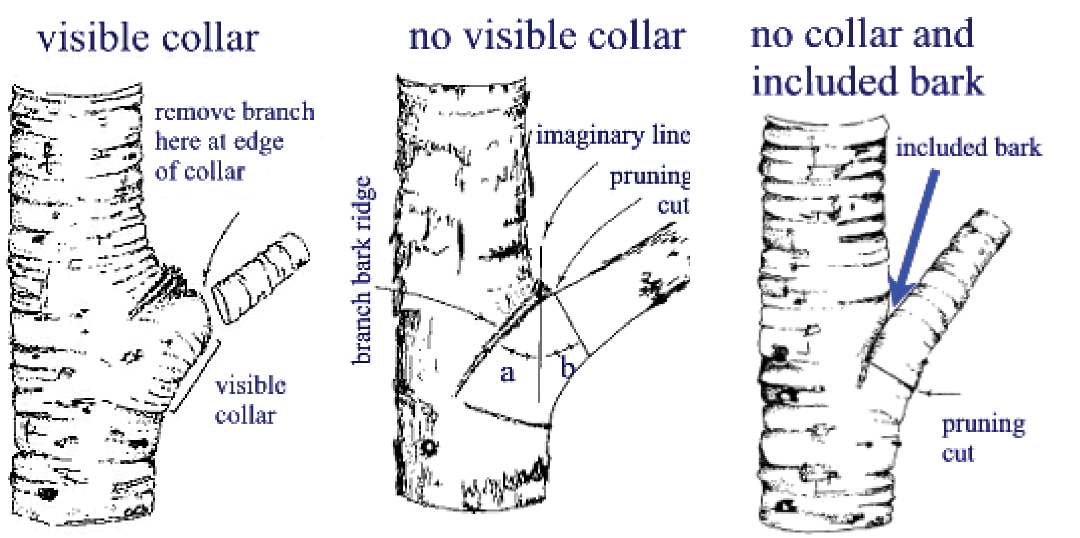


Figure 7-1. Types of pruning cuts with collar, no visible collar, and with included bark. (Courtesy of Edward F. Gilman, University of Florida)

reports about 1000 tornadoes per year. The National Weather Service estimates that Mississippi experiences 26 tornadoes per year, and has recorded up to 99 in a single year during 2005. The normal season of tornado activity is between November and April, with March and April designated as the months for peak activity.

Like hurricanes, tornadoes are commonly associated with powerful thunderstorms that produce large amounts of precipitation which increases the hazard for localized flooding. What makes tornadoes different is:

1. the unpredictability of the location where they will occur,
2. the suddenness in which they may be generated,
3. the size and wind strength that they may produce, and
4. the duration of time that they may pose a threat.

Individual tornadoes vary in size and may stretch more than a mile across, but most are generally about 250 feet wide, with an average wind speed of 110 miles per hour (mph). However, some may attain wind speeds of greater than 300 mph and stay on the ground for dozens of miles. Size is not equated with strength, and it is important to note that small tornadoes can be very violent, while larger ones can be weak enough to cause little damage.

The Fujita Tornado Damage Intensity Scale, also known as the Fujita-Pearson or FPP Scale, was adopted in 1971 as the internationally accepted measurement of tornado strength. The six-tiered system ranks tornadoes according to wind speed, in addition to the level of destruction caused to both man-made and natural materials.

F0- (40-72 mph)
F1- (73-112 mph)
F2 – (113-157 mph)
F3- (158-206 mph)
F4- (207- 260 mph)
F5- (261- 318mph)
F6- (319 mph and greater)

While the Saffir-Simpson Scale categorizes hurricanes by simply measuring wind speed, the Fujita-Pearson Scale takes into account the actual damage inflicted upon trees and other structures. Levels F0-F1 are described as gale-force tornadoes strong enough to break off branches and topple shallow-rooted trees, and these account for 74% of all tornadoes recorded from 1950-1994. Levels F2-F3 account for 25% of the remainder, and are characterized as severe tornadoes capable of snapping tree trunks in-two or uprooting large trees entirely.

Levels F4-F5 occur less than 1% of the time, but are violent enough to debark remaining trees that are still standing. These tornadoes may also completely level wood-framed houses and launch automobile-sized projectiles through the air for more than 100 yards. Level F6 funnel clouds are theoretical and have yet to be documented, and thus their damage to the urban forest canopy cannot be accurately predicted.

Michael Raphael/FEMA

Management Strategies

Because the injury to trees resulting from tornadoes is so similar to that caused by hurricanes, strategies for damage prevention and mitigation are much the same. Two of the most critical considerations are choosing the correct species with regard to storm tolerance, and proper placement of trees within the urban landscape setting. Refer to the previous section on hurricanes, and to the Appendix D, Table D-9 for storm resistant species.

Ice Storms

Severe ice storms occur each year in North America, particularly in the Midwestern and Eastern regions of the United States. Ice storms are responsible for deaths and injury of people, and devastating losses within our urban forests. Damage to electrical distribution and property, and blocked roadways due to fallen trees and limbs pose a safety concern and disrupt vital community functions. These natural disturbances typically result in monetary losses in the tens to hundreds of millions of dollars annually, and once every ten to twenty years have the potential to cause losses in the billions.

Mississippi experienced at least two severe icing events in recent years, with the most recent occurrence in 1999, and the worst on record in 1994. In February 1994, an extremely large winter storm produced ice thicknesses of 3 to 6 inches across the northern portion of the state, causing catastrophic damage in excess of $2 billion. Urban tree losses were estimated at nearly $30 million, with the total damage to commercial forests estimated at $1.3 billion. Utility damages were estimated at more than $500 million, and the 6 inches of rain produced by the storm also caused additional problems with flooding and property damage.

Winter storms may form in many ways, but all have three common components.

1. Violent winter winds created by the

arctic jet stream supply the cold temperatures and wind speed necessary for freezing cloud layers to form near ground level.

2. Warm air masses spawned in the Gulf of Mexico push evaporating moisture northward, generally during the months of October through April.
3. The collision of the different temperatures forces the warm moist air mass to "lift" above the cooler air mass. Precipitation is then deposited into the colder cloud layers below where it transforms into freezing rain, sleet, and snow.

Ice storms are often referred to as glazing storms, because of the gradual accumulation of frozen moisture on trees and other objects. Precipitation may occur in many forms including ordinary rain, sub-cooled rain (which forms glaze), and frozen rain (known as sleet). Snow in the form of pellets, flakes, or crystals combines with the other forms of moisture to create a condition known as "ice loading." Ice loading on tree branches and power lines is measured in terms of radial thickness on a scale ranging from:

- light (0 inches)
- medium (0.25 inches)
- heavy (0.50 inches).

The United States is divided into three main ice-loading districts based upon the potential risk. The upper one-third of Mississippi is in the medium range while the lower two-thirds of the state fall into the light category.

The U. S. National Weather Service (NWS) defines ice storms as the accumulation of at least ¼ inch (0.625 cm) of ice on exposed surfaces. The NWS maintains records on the annual mean number of days that freezing rain occurs across each region, and Mississippi along with other coastal states experiences 1-2 days per year. It is the presence of this freezing rain in combination with sub-freezing ground level temperatures (32° F, 0° C or below) that causes ice to form and accumulate in large amounts.

Most ice storms last only a few hours, but may occur over several days depending on weather patterns. Trees, power lines, and buildings are all extremely vulnerable to ice damage, and what makes these storms so formidable is the duration of freezing weather that often accompanies these events. Hard freeze conditions well in advance of a storm may allow ice to remain frozen in place for several days, and continued freezing weather afterwards can greatly delay response and relief efforts due to lack of accessibility to affected sites.

Ice accumulation on stems generally ranges from a trace up to one inch, and in extreme

cases up to eight inches of stem encasement have been reported. Accumulations of ¼ to ½ inch can cause small branches and weak limbs to break, whereas ice buildup of ½ to 1 inch or greater can cause failure of larger branches. Ice accumulations can increase the weight of branches by a factor of 10 to 100 times, and branch failure occurs when the weight of ice loading exceeds wood resistance to failure.

The severity of damage increases with greater accumulations of ice, and residual damage may occur several months or even years later as branches and trunks weakened by ice loading eventually fail. Branches left intact after a storm commonly suffer a separation of bark from the cambial layer that may remain undetected until much later when secondary pest problems emerge. Disease and insects help hasten decay, and some of the best strategies for minimizing ice injury lie in proper pruning and other cultural practices that maintain canopy balance and reduce the risk of trunk splitting.

As in the case of other storm events, several similar factors increase the risk for ice injury.

1. Tree specie resistance and tree placement.
2. Tree age, structure, and pre-existing health condition.
3. Wind strength and duration.

Ice Resistant Species

Juvenile and mature trees that possess excurrent (conical) branching patterns, flexible branches with strong attachments, and a low surface area of lateral branches are generally resistant to ice storms. Many species of narrowleaf evergreens fall into this category, such as Eastern red cedar (*Juniperus virginiana*) and hemlock (*Tsuga canadensis*), with an upright, pyramidal growth habit.

Deciduous trees have the most problems with ice, and the least resistant among them tend to lack one or more of the attributes just mentioned. Size does matter, and dominant and codominant species that rank as large to medium trees are more susceptible than intermediate or understory species. American elm (*Ulmus americana*) and Eastern cottonwood (*Populus deltoides*) are much less resistant than the lower-growing red buckeye (*Aesculus pavia*) and hophornbeam (*Ostrya virginiana*).

Branch breakage is more prevalent in weakwooded species like basswood (*Tilia spp.*), sugar hackberry (*Celtis laevigata*), and silver maple (*Acer saccharinum*). Perhaps as equally important as wood strength is the detrimental tendency for certain species to produce a large amount of included bark within branch junctures, such as Bradford pear (*Pyrus calleryana* 'Bradford'). Regardless of species, the wood strength of sound branches matters less than the ability of a tree to withstand breakage at branch junctures.

Fine branching patterns on lateral limbs of species such as black locust (*Robinia pseudoacacia*) and willow (*Salix spp.*) also make them more prone to ice collection. Conversely, trees with coarse branching patterns like black walnut (*Juglans nigra*) and ginkgo (*Ginkgo biloba*) accumulate less ice and incur less breakage during storms. Some species including tulip poplar (*Liriodendron tulipifera*) exhibit a beneficial excurrent branching habit when juvenile, then become less resistant at maturity when the crown broadens into a more decurrent form.

Trees with a greater taper of the main trunk or with buttresses are able to support more mass and tend to have greater resistance, and some examples are baldcypress (*Taxodium distichum*) and blackgum (*Nyssa sylvatica*). Shallower-rooted species such as red oak (*Quercus falcata*) are more prone to tipping than deep-rooted species like white oak (*Quercus alba*) or sweetgum (*Liquidambar styraciflua*). For a more complete listing of specie resistance, refer to Table D-10, and also Table D9- in Appendix D).

Placement in the landscape plays a critical role in the amount of risk to which trees are subjected. Trees with unbalanced or restricted root systems that are planted on slopes or near hardscapes such as sidewalks and pavement have a greater probability of tipping. Trees planted facing a northeastern exposure are at greatest risk due to imbalances in crowns and roots, so extra consideration should be taken when evaluating susceptible species placed in these locations.

Ice storm damage can be placed into five general categories that are used to determine whether to salvage or remove trees completely.

1. Broken branches
2. Trunk bending
3. Splitting of main or codominant stems
4. Complete trunk failure

Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, , Bugwood.org

5. Tipping or uprooting

Refer to the Pre-Storm Checklist for Existing Trees and the Hazard Tree Removal Decisions criteria in the Hurricanes section of this chapter for more information on tree evaluation.

Trunk bending is one form of injury that is possibly unique to ice storms, due to the excessive weight accumulated in the crowns of trees. As earlier stated, broad crowns and fine tip branching increase the susceptibility to bending, and several factors are used to determine the extent of damage. Injury may be inflicted on individual branches, and may not be immediately evident. Hidden damage can manifest itself in cracks that run parallel to the branch, and originate near or at the point of attachment. Cracked branches should be identified and removed as soon as possible to reduce the risk of more extensive damage.

Trees that bend rather than breaking under the weight of ice will, in most cases, return to their pre-storm form once the load is dissipated by melting. Young trees can often recover from trunk bending, as long as bark splitting is not extended into the cambial layer, and the bend angle is higher than 1/3 of the total tree height. Bends at the lower 1/3 of the trunk and below should be given special attention, as internal cracks may have been created that could form a weak point in the future. Small bent trees can be staked into an upright position to provide support, and monitored frequently while the stem grows and strengthens.

In conclusion, ice storm frequency and severity in the Eastern United States prompts the need for ice storm planning and preparation to be included in the urban forest management process. Like other natural disturbances they are impossible to prevent, but can be mitigated by taking the proper steps to reduce their impact on trees, buildings, and infrastructure.

Wildfires and Drought

Fires are an integral part of the natural environment, and prescribed under the right conditions, are commonly utilized as a valuable tool in clearing and controlling unwanted vegetation within the forest understory. However, unplanned forest fires can easily spread out of control, resulting in enormous losses to the urban forest canopy, to constructed property,

Joseph O'Brien, USDA Forest Service, Bugwood.org and to human life. The continuing trend for urban populations to expand into remote, densely forested environments has significantly elevated the risk of wildfire occurrence, and has greatly increased the liability and cost of recovery from wildfires.

Wildfires are defined as incendiary events which engulf timber and other flammable materials, burning with an intensity that requires either natural or artificial intervention in order to combat and quell the overwhelming effects. Historically, wildfires were caused naturally by lightning strikes, however, humans account for an increasing number of fire ignitions each year. In Mississippi, fires ignited by lightning are rare, and most are caused by humans with roughly 50% originating from escaped debris with the remaining 50% resulting from arson. Fires are frequently started accidentally by campers accessing public lands, or by landowners engaged in the practice of private forest vegetation management. Sadly, there is also an increase in the number of fires purposefully ignited by arsonists. Regardless of the cause, wildfires rank among the most preventable and manageable detriments to the urban forest community.

Hazardous fire activity is most often associated with the drier climates of the Western United States, but is also prevalent in the humid Southeast. In Mississippi, about 5,000 wildfires occur each year, burning more than 60,000 acres. Roughly 97% of all wildfires can be quickly controlled and suppressed, however, at least 3% of the time they burn so intensely that there is little that firefighters can do.

Components of the Fire Environment

There are three primary components that affect fire behavior: weather, topography, and available fuel. The favorability and combination of these environmental factors will determine the:

1. likelihood that a wildfire will start,
2. speed and intensity of the burn,
3. direction a fire will spread,
4. ability to control and extinguish a wildfire.

Urban development in closer proximity to unmanaged, heavily wooded areas is converting communities that were once considered rural into suburban and urban environments. Improved fire prevention and protection methods are the keys to minimizing the threats posed by topography and fuel load. The best opportunities to reduce the probability of wildfire damage lie in sustainable urban land management and standardized vegetation control practices. Information on how to design, construct, and maintain a home or community so that they may withstand a wildfire without the aid of firefighting resources are available through the Mississippi Firewise Program at www.mfc.state.ms.us/firewise.htm.

Weather

As in the case of other natural disturbances, weather is the one factor that man has the least ability to predict or control. Therefore, it is crucial to develop strategies that plan contingently for the hazardous weather conditions that promote wildfires. Wildfire risk is directly related to natural cycles of seasonal drought, and is greatest during prolonged periods with high temperatures and below average rainfall.


Dale Wade, Rx Fire Doctor, Bugwood.org

The National Weather Service (NWS) Forecast Office is an essential source of up-to-date information on rainfall, temperature outlook, and fuel moisture levels. The NWS works closely in conjunction with local and state agencies to monitor current weather conditions, and to announce fireweather forecasts based upon 8-14 day, 30-day, and 90-day outlooks. Current conditions such as relative humidity and wind speed are recorded and posted statewide on public radio, television, and non-profit Web sites at www.nws.noaa.gov and www.weather.noaa.gov. Red Flag Warnings, Area Spot Forecasts, and other Fireweather Watch statements are reported daily, and are provided to local news media sources.

Fire danger indices are updated hourly by Area Fire Weather Watch Stations located in southern regional hubs like Jackson, Mississippi, New Orleans, Louisiana, Little Rock, Arkansas, and Memphis, Tennessee. Alabama also has three locations in Mobile, Birmingham, and Huntsville. National Fire Defense and Response Service (NFDRS) stations are also scattered across each state to supply additional links in the monitoring network. State Forestry Commission personnel and volunteer fire responders often provide the first line of defense in helping to detect, suppress, and evacuate when wildfires encroach upon urban settings.

Drought

Drought conditions are posted daily for all 50 states using the **Keetch Byram Drought Index (KBDI)**. The purpose of this research tool is to develop a predictive method of correlation between dry weather and wildfire activity. The KBDI is a continuous reference scale that measures moisture deficits by estimation of dryness in the soil and duff layers. The index value increases for each day without rain, and decreases for each day when rainfall occurs. Daily high temperatures also affect the KBDI values, which range on a scale from 0 - 800 (very low to severe).

The KBDI operates on the assumption that 8 inches of moisture are present in a saturated soil, and that the moisture is readily available to the vegetation present. The depth of soil required to hold 8 inches of moisture varies greatly among soil types (clay = 25 inches, loam = 30 inches, sand = 80 inches). Prolonged drought induces a high KBDI value, and influences fire intensity because more fuel becomes available for combustion. As the moisture content within the forest canopy evaporates, the flammability index increases, and the accelerated drying of organic materials within the soil layer exacerbates fire suppression efforts.

High KBDI values are an indication that conditions are favorable for wildfires, although drought by itself is not a prerequisite for fire outbreak. Other factors such as wind, temperature, relative humidity, and atmospheric stability play a major role in determining actual fire danger. Many states have developed predictive KBDI values based upon seasonal weather data collected over many years. Florida, for example, has developed a classification system which averages KBDI scores for winter, spring, summer, and fall. Average precipitation values collected over a 35-year period are ranked into a tiered system from very low-low-normal-moderate-severe, with "normal" classifications established for north, central, and southern regions of the state. Departures from normal values in moisture levels are compared with fluctuations in fire activity during each season for each region.

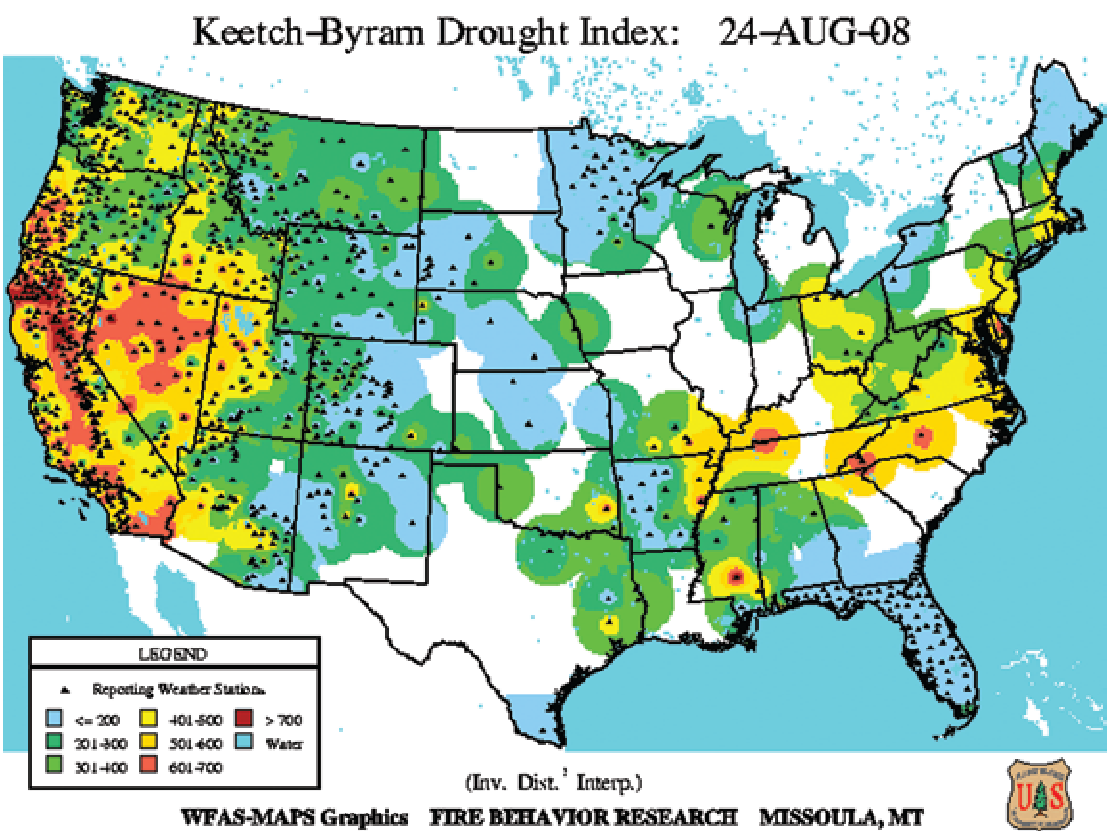
Threshold KBDI values are difficult to establish and accurately predict for each month of the year, primarily due to the combination of climatic factors previously mentioned. For example, September and October are historically some of the driest months on record, yet they typically produce some of the lowest annual KBDI values. Conversely, KBDI values understandably peak in the heated summer months of May – July, yet they also begin to elevate as early as January - April when rainfall is normally abundant. Some of the fluctuation in values may be attributed to the seasonal usage of soil moisture by plants. Most plant species adapted to temperate zones utilize much less water as they enter into winter dormancy, and then absorb increasing amounts of moisture as they begin spring vegetative growth.

Regardless of statistical limitations, the KBDI is an invaluable tool in establishing baseline data to demonstrate a predictable relationship between moisture deficits and wildfire risk. The index categorizes significant fire seasons based upon a value of 1.0 = moderate to 1.5 = severe. In data collected from 1981 to 1998, results show that when a KBDI went above 1.0 (moderate drought), a moderate to severe fire season occurred 98.5% of the time. When the KBDI exceeded 1.5, the fire season was always above the average in the moderate to severe range. More information about the KBDI study is available at the Florida Division of Forestry Web site, at www.fl.dof.com/fire_weather/information

Visit the Mississippi Forestry Commission Web site at www.mfc.state.ms.us for daily updated KBDI maps tracking drought trends across the state. The site also has several links to additional resource information on wildfire and drought assistance programs.

Topography

The lay of the land is another factor that is not easily subject to change, especially after an urban environment has been permanently established. Preventive action is therefore the best strategy in saving lives and property, and collaboration is essential between urban forest managers, planners and contractors, and community residents. Though it is not possible to "fire-proof" the urban forest, several steps can



be taken to reduce wildfire impact:

1. Vegetation management around buildings to create defensible space for protection,
2. Use of fire-resistant building materials in homes and other structures,
3. Design subdivisions and other urban developments using fire-safe measures,
4. Ensure planning and coordination among all emergency response agencies, and
5. Maintain accessibility for emergency response vehicles and equipment.

Defensible space is a relatively new concept usually expressed as a distance extending outward from the boundaries of a house or other building. This distance varies according to the **types of vegetation** growing in close proximity, and the **steepness of the slope** in each direction. Vegetative types are loosely categorized as shrubs, trees, or grasses and groundcovers. Steepness of the terrain may be categorized as flat to gentle sloping (0-20%), moderately steep (21-40%), or very steep (40% or more). What may seem surprising is that the risk for fire encroachment actually increases with the steepness of the slope, and spacing increases from 30-feet for all vegetative types on gentle slopes, up to 100-200 feet for densely crowded trees and shrubs on steep grades. Separation distance between individual tree canopies is also recommended to reduce fire spread, and is again based upon the degree of slope- (10-feet for gentle), (20-feet for moderate), and (30-feet for steepest grades).

Fuel

Obviously, not every setting allows for the adequate creation of defensible space, and other practices can be implemented to reduce the fuel load that a fire may consume. Combustible materials such as dead trees and other dried vegetation should be removed from at-risk areas as often as possible to minimize fuel accumulation. Annual maintenance planning for timely pruning and thatch removal will also reduce future fire hazards, along with supplying adequate irrigation to maintain high moisture content within the fuel load zone.

Firescaping is landscape design that reduces community vulnerability to wildfire, and like other preventive methods, it works best when owners of contiguous properties approach the task together in a comprehensive fashion. Use of "fire smart" species that are more flame resistant, safe placement of landscape plants, and creation of fuel breaks are a few suggestions that can greatly decrease the potential for fire damage. Recommended large tree species include oak, maple, ash, hickory, and yellow poplar, while medium-sized choices include dogwood, crape myrtle, persimmon, and crabapple. Shrubs such as holly, nandina, witch hazel, azalea, and a number of other evergreens exhibit good fire tolerance, in addition to tough groundcovers like jasmine, periwinkle, pachysandra, liriope, and creeping phlox.

Safe plant placement around buildings can be even more crucial than the species that are planted. Trees should be installed with "size at maturity" in mind, and should be kept pruned at a minimum of 15 feet from chimneys and power lines. Flying embers can ignite single trees or shrubs that may pose an extreme hazard if planted within 10 feet of windows.

Fire breaks can help reduce flame intensity by separating the supply of flammable fuels. Examples include open lawns, driveways, walks, parking areas, patios, or privacy fences constructed of non-flammable materials such as stone or cement. Water features like streams or garden ponds can also serve as effective fire barriers, and even dry stream beds are beneficial when layered with rock mulches or riprap.

Wildfire Control

Since 1926, the Mississippi Forestry Commission (MFC) has led the charge statewide in wildfire **prevention**, **detection**, and **suppression**. Much of the positive impact is due to assistance programs provided through the state's volunteer fire departments, in addition to the many other services offered under the umbrella of Forest Protection:

1. Burn Bans
2. Burning Permits
3. Federal Access Personal Property Program (FEPP)
4. Fire Law Enforcement
5. Predictive Services Division (Fire Weather)
6. Southern Regional Fire Training Center (SRFTC)
7. Volunteer Fire Assistance Program (VFA)
8. Wildfire Detection and Reporting
9. Wildfire Control

Burn bans are authorized by the MFC, and issued individually for each county in the state. Bans are issued with a starting and an ending date, dependent upon current and future weather conditions. It is against the law to ignite fires during these periods of extreme fire hazard, and those engaged in fire starting activities during that time are subject to stiff fines or even incarceration (even when the sources are recreational like campfires or fireworks). **Burning permits** are issued by the MFC to municipalities and to individuals practicing prescribed vegetation management, however, they are not valid and are rendered void during extreme drought conditions.

The MFC is also charged with **fire law enforcement** duties, and is responsible for suppressing wildfires on nearly 20 million acres of timbered and uncultivated lands 24-hours a day, 365 days a year. **Wildfire detection and reporting** is accomplished chiefly through airplane surveillance, coupled with the public's reporting efforts using toll-free telephone numbers provided by the MFC. County fire suppression crews are then alerted by a central dispatching center located at each district office, and **volunteer fire assistance** is also dispatched when applicable.

Listed below are several state codes used by the MFC to enforce laws pertaining to wildfire control, including the **Federal Access Personal Property (FEPP)** mandate. Burning Permit guidelines are provided, along with reporting procedures and district office contact information.

MS Code Section 49-19-3 mandates the Mississippi Forestry Commission "Take such action and provide and maintain such organized means as may seem necessary and expedient to prevent, control, and extinguish forest fires, including the enforcement of any and all laws pertaining to the protection of forests and woodlands."

MS Code Section 49-19-25 Federal Access Personal Property (FEPP) authorizes the Mississippi Forestry Commission to enter any and all lands for the purpose of suppressing and controlling any fires declared a public nuisance by reason of its menace to life and property. This law also authorizes the Mississippi Forestry Commission to charge for all costs associated with suppressing the fire. Any open cistern or well, which has been abandoned or is not longer used for the purpose of cistern or well is hereby declared to be public nuisance by reason of its menace to life and property, and the Mississippi Forestry Commission is authorized to seal such cistern or well for a reasonable fee.

MS Code Section 97-17-13 establishes the penalty and fines for wood arson (willfully or negligently firing woods, marsh, meadows, etc).

MS Code Section 95-5-25 establishes the penalty and fine for wantonly negligently or carelessly allowing any fire to get onto the lands of another, he shall be liable.

Burning Permits: In conjunction with the Mississippi Department of Environmental Quality, the Mississippi Forestry Commission issues burning permits based on the daily fire weather forecast. Permits are required for any fire set for a recognized agricultural and/or forestry purpose. Call your local Central Dispatch Center to inquire about a burning permit. Be prepared to answer the following questions: Type of burning (agriculture or forestry); Number of acres; Forestry purpose (hazard reduction, control undesirable species, control disease, site prep, wildlife mgt or other); Landowner name, Person responsible for fire; Address, Telephone number; Location of property (40, section, township and range); Beginning and end date and time of fire.

To Report A Wildfire: Contact the Central Dispatch for your area from the list below or from the MFC Central Dispatch map.

District Central Dispath Information

Northeast District
Phone: 662-840-0948
Toll Free: 1-800-681-8760

Alcorn, Benton, Calhoun, Chickasaw, Choctaw, Clay, Itawamba, Lafayette, Lee, Lowndes, Marshall, Monroe, Noxubee, Oktibbeha, Pontotoc, Prentiss, Tippah, Tishomingo, Union, Webster, Winston

Northwest District
Toll Free: 1-877-226-5414

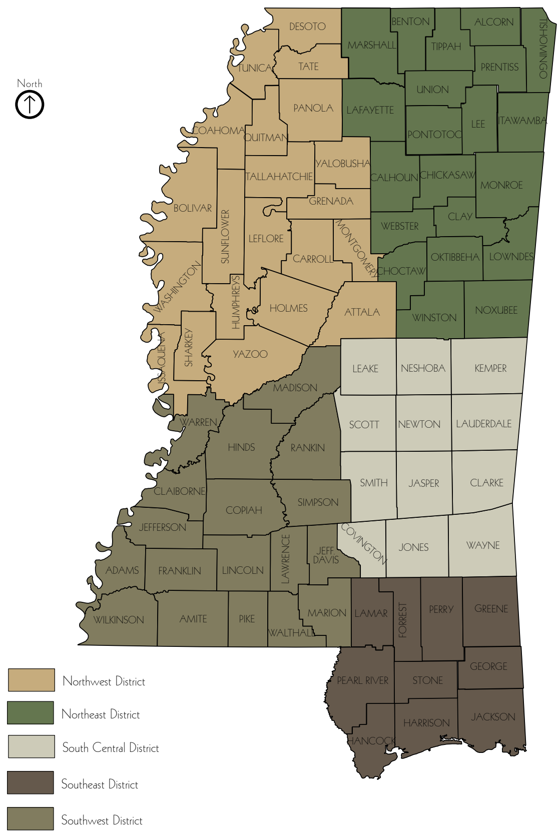
Attala, Bolivar, Carroll, Coahoma, Desota, Grenada, Holmes, Humphreys, Issaquena, Leflore, Montgomery, Panola, Quitman, Sharkey, Sunflower, Tallahatchie, Tate, Tunica, Washington, Yalobusha, Yazoo

Southeast District
Toll Free: 1-800-240-5161

Forrest, George, Greene, Hancock, Harrison, Jackson, Lamar, Pearl River, Perry, Stone

South Central District
Toll Free: 1-800-736-9115

Clarke, Covington, Jasper, Jones, Kember, Lauderdale, Leake, Neshoba, Newton, Scott, Smith, Wayne



Southwest District
Toll Free: 1-888-823-3473

Adams, Amite, Claiborne, Copiah, Franklin, Hinds, Jefferson, Jefferson Davis, Lawrence, Lincoln, Madison, Marion, Pike, Rankin, Simpson, Walthall, Warren, Wilkinson

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Glossary

A

Abatement Reducing the degree or intensity of, or eliminating, pollution.

Absorption The uptake of water, other fluids, or dissolved chemicals by a cell or an organism (as tree roots absorb dissolved nutrients in soil).

Air pollutant Any substance in air that could, in high enough concentration, harm man, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of airborne matter capable of being airborne. They may be in the form of solid particles, liquid droplets, gases, or in combination thereof. Generally, they fall into two main groups: (1) those emitted directly from identifiable sources and (2) those produced in the air by interaction between two or more primary pollutants, or by reaction with normal atmospheric constituents, with or without photoactivation. Exclusive of pollen, fog, and dust, which are of natural origin, about 100 contaminants have been identified. Air pollutants are often grouped in categories for ease in classification; some of the categories are: solids, sulfur compounds, volatile organic chemicals, particulate matter, nitrogen compounds, oxygen compounds, halogen compounds, radioactive compounds, and odors.

Air pollution The presence of contaminants or pollutant substances in the air that interfere with human health or welfare, or produce other harmful environmental effects.

Ambient Surrounding or encircling. Often used to describe air and water temperatures.

B

Basin The largest single watershed management unit for water planning that combines the drainage of a series of subbasins. Often has a total area of more than a thousand square miles.

Benefit-cost analysis An economic method for assessing the benefits and costs of achieving alternative health-based standards at given levels of health protection.

Best Management Practices (BMPs) Forest management practices, developed pursuant to federal water quality legislation, to minimize or prevent non-point source water pollution. Often in more general usage referring to any good forest stewardship practices.

Biodiversity Refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequencies. For biological diversity, these items are organized at many levels, ranging from complete ecosystems to the biochemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, and genes.

Biogenic Volatile Organic Compounds (BVOCs) Hydrocarbon compounds from vegetation (e.g., isoprene, monoterpene) that exist in the ambient air and contribute to the formation of smog and/or may themselves be toxic.

Biological integrity The ability to support and maintain balanced, integrated, functionality in the natural habitat of a given region. Concept is applied primarily in drinking water management.

Biomass All of the living material in a given area; often refers to vegetation.

Bioremediation Use of living organisms to clean up oil spills or remove other pollutants from soil, water, or wastewater; use of organisms such as non-harmful insects to remove agricultural pests or counteract diseases of trees, plants, and garden soil.

Bioretention A technique that uses parking lot islands, planting strips, or swales to collect and filter urban stormwater (may include grass and sand filters, loamy soils, mulch, shallow ponding, and native trees and shrubs).

Buffer An area adjacent to a water body, residence, subdivision, place of business, or roadway where development is restricted or prohibited.

Buffer averaging A technique of buffer flexibility whereby a buffer is permitted to become narrower at some points along the stream (e.g., to allow for an existing structure or to recover a lost lot), as long as the average width of the buffer meets the minimum requirement.

Buffer expansion An increase in the base width of the stream buffer to incorporate floodplains, steep slopes, adjacent wetlands, or to protect higher order streams and rivers.

Buffer strips Strips of grass or other erosion-resisting vegetation between or below cultivated strips or fields.

C

Carbon sequestration Annual net rate that a tree removes CO_2 from the atmosphere through the processes of photosynthesis and respiration (kg CO_2/tree/year).

Catchment A development pattern that arranges the layout of buildings on a compact area of the site so as to reserve a portion of the site for common open space or greenspace that is protected in perpetuity.

Coastal zone Lands and waters adjacent to the coast that exert an influence on the uses of the sea and its ecology, or whose uses and ecology are affected by the sea.

Combined sewer overflows Discharge of a mixture of stormwater and domestic waste when the flow capacity of a sewer system is exceeded during rainstorms.

Combined sewers A sewer system that carries both sewage and stormwater runoff. Normally, its entire flow goes to a waste treatment plant, but during a heavy storm, the volume of water may be so great as to cause overflows of untreated mixtures of stormwater and sewage into receiving waters. Stormwater runoff may also carry toxic chemicals from industrial areas or streets into the sewer system.

Community water system A public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

Compliance monitoring Collection and evaluation of data, including self-monitoring reports, and verification to show whether pollutant concentrations and loads contained in permitted discharges are in compliance with the limits and conditions specified in the permit.

Compliance schedule A negotiated agreement between a pollution source and a government agency that specifies dates and procedures by which a source will reduce emissions and, thereby, comply with a regulation.

Conservation easement A legal agreement that a property owner makes to restrict the type and amount of development that may take place on his or her property. The easement spells out the right the landowner retains as well as the restrictions on use of the property.

Consumptive water use Water removed from available supplies without return to a water resources system, e.g. water used in manufacturing, agriculture, and food preparation.

Contaminant Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

Contamination Introduction into water, air, and soil of microorganisms, chemicals, toxic substances, wastes, or wastewater in a concentration that makes the medium unfit for its next intended use. Also applies to surfaces of objects, buildings, and various household and agricultural use products.

Continuous discharge A routine release to the environment that occurs without interruption, except for infrequent shutdowns for maintenance, process changes, etc.

Conveyance loss Water loss in pipes, channels, conduits, ditches by leakage or evaporation.

Crossing width Minimum width of right-of-way to allow for maintenance access of the buffer.

D

Delineation The process of drawing or tracing the outline of or sketching out boundaries, edges, areas, etc.

Density compensation A scheme that grants a developer credit for additional density elsewhere on a site, in compensation for developable land that has been lost due to a buffer requirement.

Direct runoff Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.

Discharge Flow of surface water in a stream or canal or the outflow of ground water from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.

Disturbance Any event or series of events that disrupt ecosystem, community, or population structure and alters the physical environment.

Diversion 1. Use of part of a stream flow as water supply. 2. A channel with a supporting ridge on the lower side constructed across a slope to divert water at a non-erosive velocity to sites where it can be used and disposed.

Drainage basin The area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel.

E

Ecological impact The effect that a man-caused or natural activity has on living organisms and their non-living (abiotic) environment.

Ecological integrity A living system exhibits integrity if, when subjected to disturbance, it sustains and organizes self-correcting ability to recover toward a biomass end-state that is normal for that system. End-states other than the pristine or naturally whole may be accepted as normal and good.

Ecosystem The interacting system of a biological community and its non-living environmental surroundings.

Effluent Wastewater—treated or untreated—that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Emission Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Environment The sum of all external conditions affecting the life, development and survival of an organism.

Erosion The wearing away of the land surface by rain, running water, wind, ice, gravity, or other natural or anthropogenic agents, including such processes as gravitational creep and tillage.

Estuary Region of interaction between rivers and near-shore ocean waters, where tidal action and river flow mix fresh and salt water. Such areas include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife.

Eutrophication Nutrient enrichment (e.g., nitrogen, phosphorus, and carbon) from sewage effluent, runoff, or atmospheric deposition to surface waters.) This process can increase the growth of algae and aquatic plants and ultimately leave water-bodies devoid of most life, impede navigation, and result in aesthetic nuisances.

Evapotranspiration The loss of water from the soil both by evaporation and by transpiration from the plants growing in the soil.

F

Fill Man-made deposits of natural soils or rock products and waste materials.

Filter strip Strip or area of vegetation used for removing sediment, organic matter, and other pollutants from runoff and wastewater.

Filtration A treatment process, under the control of qualified operators, for removing solid (particulate) matter from water by means of porous media such as sand or a man-made filter; often used to remove particles that contain pathogens.

First-order stream A stream that has no tributaries or branches.

Floodplain Areas adjacent to a stream or river that are subject to flooding or inundation during a storm event that occurs, on average, once every 100 years. The flat or nearly flat land along a river or stream or in a tidal area that is covered by water during a flood.

G

Grassed waterway Natural or constructed watercourse or outlet that is shaped or graded and established in suitable vegetation for the disposal of runoff water without erosion.

Gray water Domestic wastewater composed of wash water from kitchen, bathroom, and laundry sinks, tubs, and washers.

Greenspace Urban trees, forests, and associated vegetation in and around human settlements, ranging from small communities in rural settings to metropolitan regions.

Ground cover Plants grown to keep soil from eroding.

Ground water The supply of fresh water found beneath the Earth's surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants or leaking underground storage tanks.

Ground-water discharge Ground water entering near coastal waters which has been contaminated by landfill leachate, deep well injection of hazardous wastes, septic tanks, etc.

H

Habitat The place where a plant or animal species naturally lives and grows.

Hazardous substance 1. Any material that poses a threat to human health and/or the environment. Typical hazardous substances are toxic, corrosive, ignitable, explosive, or chemically reactive. 2. Any substance designated by EPA to be reported if a designated quantity of the substance is spilled in the waters of the United States or is otherwise released into the environment.

Hazardous waste By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

Headwater stream A term for the smaller first- and second-order tributary streams in a drainage network.

Heat island effect A "dome" of elevated temperatures over an urban area caused by structural and pavement heat fluxes and pollutant emissions.

Heat islands Areas of elevated temperatures in the urban environment caused by structural and pavement heat fluxes and pollutant emissions.

Holding pond A pond or reservoir, usually made of earth, built to store polluted runoff.

Hydraulic gradient In general, the direction of groundwater flow due to changes in the depth of the water table.

Hydrologic cycle Movement or exchange of water between the atmosphere and earth.

Hydrology A science dealing with the properties, distribution, and circulation of water.

Hypoxia/hypoxic waters Waters with dissolved oxygen concentrations of less than 2 ppm, the level generally accepted as the minimum required for most marine life to survive and reproduce.

I

Impermeable Not easily penetrated. The property of a material or soil that does not allow, or allows only with great difficulty, the movement or passage of water.

Impervious cover or surface A surface that cannot be penetrated by water (i.e., pavement, rock, or a rooftop) and thereby prevents infiltration and generates runoff. Often determined as what is not green at the development site.

Imperviousness The percentage of surface cover that cannot be penetrated by water within a development site or watershed.

Impoundment A body of water or sludge confined by a dam, dike, floodgate, or other barrier.

Indirect discharge Introduction of pollutants from a non-domestic source into a publicly owned waste-treatment system. Indirect dischargers can be commercial or industrial facilities whose wastes enter local sewers.

Indirect source Any facility or building, property, road or parking area that attracts motor vehicle traffic and, indirectly, causes pollution.

Infiltration 1. The penetration of water through the ground surface into sub-surface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. 2. The technique of applying large volumes of wastewater to land to penetrate the surface and percolate through the underlying soil.

Infiltration rate The quantity of water that can enter the soil in a specified time interval.

Inflow Entry of extraneous rain water into a sewer system from sources other than infiltration, such as basement drains, manholes, storm drains, and street washing.

Instream use Water use taking place within a stream channel; e.g., hydro-electric power generation, navigation, water quality improvement, fish propagation, recreation.

Integrated pest management (IPM) A mixture of chemical and other, non-pesticide, methods to control pests.

Integrated waste management Using a variety of practices to handle municipal solid waste; can include source reduction, recycling, incineration, and landfilling.

Interception Amount of rainfall held on tree leaves and stem surfaces.

Intermittent streams The smallest channels in the stream network that only have running water during a storm event.

Interstate waters Waters that flow across or form part of state or international boundaries; e.g. the Great Lakes, the Mississippi River, or coastal waters.

L

Land application Discharge of wastewater onto the ground for treatment or reuse.

Landscape The traits, patterns, and structure of a specific geographic area, including its biological composition, its physical environment, and its anthropogenic or social patterns. An area where interacting ecosystems are grouped and repeated in similar form.

Large water system A water system that services more than 50,000 customers.

Leachate Water that collects contaminants as it trickles through wastes, pesticides or fertilizers. Leaching may occur in farming areas, feedlots, and landfills, and may result in hazardous substances entering surface water, ground water, or soil.

Leaching The process by which soluble constituents are dissolved and filtered through the soil by a percolating fluid.

Litter 1. The highly visible portion of solid waste carelessly discarded outside the regular garbage and trash collection and disposal system. 2. Leaves and twigs fallen from forest trees.

Littoral zone 1. That portion of a body of fresh water extending from the shoreline lakeward to the limit of occupancy of rooted plants. 2. A strip of land along the shoreline between the high and low water levels.

M

Marsh A type of wetland that does not accumulate appreciable peat deposits and is dominated by herbaceous vegetation. Marshes may be either fresh or saltwater, tidal or non-tidal.

Medium-size water system A water system that serves 3,300 to 50,000 customers.

Mitigation Measures taken to reduce adverse impacts on the environment.

Morphology The form and structure of an organism or one of its parts, can also refer to water bodies such as streams, rivers, and lakes.

Mulching The placement of grass, wood chips, straw, or synthetic material on the soil to prevent erosion, slow weed growth, prevent soil packing, and maintain cooler and warmer soil temperatures depending on season.

Municipal discharge Discharge of effluent from wastewater treatment plants which receive wastewater from households, commercial establishments, and industries in the coastal drainage basin. Combined sewer/separate storm overflows are included in this category.

Municipal sewage Wastes (mostly liquid) originating from a community; may be composed of domestic wastewaters and/or industrial discharges.

Municipal sludge Semi-liquid residue remaining from the treatment of municipal water and wastewater.

Municipal solid waste Common garbage or trash generated by industries, businesses, institutions, and homes.

N

National Pollutant Discharge Elimination System (NPDES) A provision of the Clean Water Act which prohibits discharge of pollutants into waters of the United States unless a special permit is issued by EPA, a state, or, where delegated, a tribal government on an Indian reservation.

Navigable waters Traditionally, waters sufficiently deep and wide for navigation by all, or specified vessels; such waters in the United States come under federal jurisdiction and are protected by certain provisions of the Clean Water Act.

Nitrate A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and which can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. A plant nutrient and inorganic fertilizer, nitrate is found in septic systems, animal feed lots, agricultural fertilizers, manure, industrial wastewaters, sanitary landfills, and garbage dumps.

Non-community water system A public water system that is not a community water system; e.g. the water supply at a camp site or national park.

Non-conventional pollutant Any pollutant not statutorily listed or which is poorly understood by the scientific community.

Non-Point Source (NPS) pollution Pollution which is: (1) induced by natural processes, including precipitation, seepage, percolation, and runoff; (2) not traceable to any discrete or identifiable facility; and (3) controllable through the utilization of wise management practices or pollution that arises from an ill-defined and diffuse source, such as runoff from cultivated fields, agricultural lands, urban areas, or forest or wildland.

Non-potable Water that is unsafe or unpalatable to drink because it contains pollutants, contaminants, minerals, or infective agents.

Nutrient Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in wastewater, but is also applied to other essential and trace elements.

Nutrient pollution Contamination of water resources by excessive inputs of nutrients. In surface waters, excess algal production is a major concern.

O

Offstream use Water withdrawn from surface or groundwater sources for use at another place.

Organic matter Carbon-containing materials that influence the amount of water and nutrients held by the soil. High organic soils have better structure and retain nutrients and water better than medium organic soils. Low organic soils may be improved by the addition of organic materials such as compost.

Overflow rate One of the guidelines for design of the settling tanks and clarifiers in a treatment plant; used by plant operators to determine if tanks and clarifiers are over or underused.

Overland flow A land application technique that cleanses wastewater by allowing it to flow over a sloped surface. As the water flows over the surface, contaminants are absorbed and the water is collected at the bottom of the slope for reuse or water that runs across the land surface after rainfall, either before it enters a watercourse or after it overflows a watercourse.

P

Palatable water Water, at a desirable temperature, that is free from objectionable tastes, odors, colors, and turbidity.

Palustrine wetland Any inland wetland which lacks flowing water and contains ocean-derived salts in concentrations of less than 0.05%.

Particulate loading The mass of particulates per unit volume of air or water.

Particulate matter (PM_{10}) A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists. The size of the particles (10 microns or smaller, about 0.0004 inches or less) allows them to enter the air sacs (gas exchange region) deep in the lungs where they may get deposited and result in adverse health effects. PM_{10} also causes visibility reduction.

Particulates 1. Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. 2. Very small solids suspended in water; they can vary in size, shape, density and electrical charge and can be gathered together by coagulation and flocculation.

Parts Per Billion (ppb)/Parts Per Million (ppm) Units commonly used to express contamination ratios, as in establishing the maximum permissible amount of a contaminant in water, land, or air.

Peak flow The maximum rate of runoff at a given point or from a given area, during a specific period.

Percolation 1. The movement of water downward and radially through subsurface soil layers, usually continuing downward to ground water. Can also involve upward movement of water. 2. Slow seepage of water through a filter.

Perennial streams A stream channel that has running water throughout the year.

Permanent seeding The use of perennial grasses, with trees and shrubs, to stabilize the soil.

Pervious cover A vegetated area of the urban landscape where rainfall is intercepted by vegetation, and infiltrates into soil or a humus layer.

pH An expression of the intensity of the basic or acid condition of a liquid; may range from 0 to 14, where 0 is the most acid and 7 is neutral. Natural waters usually have a pH between 6.5 and 8.5.

Point source A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g. a pipe, ditch, ship, ore pit, factory smokestack.

Pollutant Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollutant load Total concentrations of point and non-source pollution contained within a given amount of water.

Porosity Degree to which soil, gravel, sediment, or rock is permeated with pores or cavities through which water or air can move.

Potable water Water that is safe for drinking and cooking.

Protected root zone The optimum space needed for a group of trees or an individual tree to retain good health and vigor.

Public water system A system that provides piped water for human consumption to at least 15 service connections or regularly serves 25 individuals.

R

Radiation loading The accumulation of radioactive materials in the atmosphere.

Rain garden A strategically located low area planted with native vegetation that intercepts runoff.

Raw sewage Untreated wastewater and its contents.

Raw water Intake water prior to any treatment or use.

Receiving waters A river, lake, ocean, stream or other watercourse into which wastewater or treated effluent is discharged.

Recharge The process by which water is added to a zone of saturation, usually by percolation from the soil surface; e.g., the recharge of an aquifer.

Recharge area A land area in which water reaches the zone of saturation from surface infiltration, e.g., where rainwater soaks through the earth to reach an aquifer.

Recharge rate The quantity of water per unit of time that replenishes or refills an aquifer.

Reservoir Any natural or artificial holding area used to store, regulate, or control water.

Restoration Measures taken to return a site to pre-violation conditions.

Retrofit Addition of a pollution control device on an existing facility without making major changes to the generating plant. Also called backfit.

Riparian Of or related to or living or located on the bank of a watercourse.

Riparian habitat Areas adjacent to rivers and streams with a differing density, diversity, and productivity of plant and animal species relative to nearby uplands.

Riparian rights Entitlement of a land owner to certain uses of water on or bordering the property, including the right to prevent diversion or misuse of upstream waters. Generally a matter of state law.

River basin The land area drained by a river and its tributaries.

Runoff That part of precipitation that flows toward the streams on the ground surface or within the ground. Runoff is composed of baseflow and surface runoff.

S

Safe water Water that does not contain harmful bacteria, toxic materials, or chemicals, and is considered safe for drinking even if it may have taste, odor, color, and certain mineral problems.

Sand filters Devices that remove some suspended solids from sewage. Air and bacteria decompose additional wastes filtering through the sand so that cleaner water drains from the bed.

Sanitary sewers Underground pipes that carry off only domestic or industrial waste, not stormwater.

Second-order stream Formed when two streams with no tributaries or branches combine.

Sediment Solid material, both mineral and organic, that is in suspension and being transported from its site of origin by the forces of air, water, gravity, or ice or oil, sand, and minerals washed from land into water, usually after rain. They pile up in reservoirs, rivers and harbors, destroying fish and wildlife habitat, and clouding the water so that sunlight cannot reach aquatic plants. Careless farming, mining, and building activities will expose sediment materials, allowing them to wash off the land after rainfall.

Sheetflow A flow condition during a storm where stormwater runoff is very shallow in depth and spread uniformly over the land surface. This sheet flow quickly changes into concentrated channel flow within several hundred feet.

Soil pH Soil pH affects the availability of nutrients and, when interpreted with texture and organic matter, indicates the limestone needs of the soil. The results are expressed in pH units, with pH 7.0 being neutral. Connecticut soils are generally somewhat acidic in the pH range of 4.5 to 6.5. Most plants except for rhododendrons, azaleas, mountain laurel and blueberries grow best at a soil pH between 6.0 and 7.0.

Soil moisture storage capacity Water content of a soil at a derived time after its complete wetting and after free drainage has become negligible.

Soil texture Texture influences the amount of water and nutrients a soil can hold. Sands, loamy sands, and sandy soils require more frequent watering and lose nutrients more readily by leaching than do fine sandy loams and loams. Silt loams, silty clay loams, and clay loams may retain excessive moisture and reduce aeration of plant roots.

Steep slope An area of a development site that is too steep to: (a) safely build on or (b) has a high potential for severe soil erosion during construction.

Storm sewer A system of pipes (separate from sanitary sewers) that carries water runoff from buildings and land surfaces.

Stormwater discharge Precipitation that does not infiltrate into the ground or evaporate due to impervious land surfaces but instead flows onto adjacent land or water areas and is routed into drain/sewer systems.

Stormwater mitigation A descriptive term for the application of one or many technological or biological practices to address and minimize flooding from storm events.

Stream buffer A variable width area of vegetation located along both sides of the stream.

Streamflow Water discharge that occurs in a natural channel.

Stream order A classification system for streams based on stream hierarchy; the smaller the stream, the lower its numerical classification. For example, a first-order stream does not have tributaries and normally originates from springs and/or seeps.

Sub-basin A term for a large watershed management unit (100 to 1,000 square miles) that combines the drainage area from a number of watersheds together, usually draining to a specific receiving water such as a lake, estuary, or river.

Subwatershed A watershed management unit whose boundaries are typically defined as all of the land draining to the point where two second-order streams combine together to form a third-order stream. A subwatershed may be a few square miles in area, and is the key geographic unit for urban stream classification and watershed-based zoning.

Surface impoundment Treatment, storage, or disposal of liquid hazardous wastes in ponds.

Surface runoff Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of non-point source pollutants in rivers, streams, and lakes.

Surface water All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc).

Suspended loads Specific sediment particles maintained in the water column by turbulence and carried with the flow of water.

Suspended solids Small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids. They resist removal by conventional means.

Swamp A type of wetland dominated by woody vegetation but without appreciable peat deposits. Swamps may be fresh or salt water and tidal or non-tidal.

T

Thermal pollution Discharge of heated water from industrial processes that can kill or injure aquatic organisms.

Tidal marsh Low, flat marshlands traversed by channels and tidal hollows, subject to tidal inundation; normally, the only vegetation present is salt-tolerant bushes and grasses.

Third-order stream Third-order streams are formed when two second-order streams combine together.

Total Dissolved Solids (TDS) All material that passes the standard glass river filter; now called total filterable residue. Term is used to reflect salinity.

Total Suspended Particles (TSP) A method of monitoring airborne particulate matter by total weight.

Total Suspended Solids (TSS) A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids".

Transpiration The process by which water vapor is lost to the atmosphere from living plants. The term can also be applied to the quantity of water thus dissipated.

Tree or Canopy cover The percent of a fixed area covered by the crown of an individual tree or delimited by the vertical projection of its outermost perimeter; small openings in the crown are included. Used to express the relative importance of individual species within a vegetation community or to express the coverage of woody species.

Turfgrass Any grass species grown as a solid mat of vegetation; often used for sod in home lawns and golf courses.

U

Urban runoff Stormwater from city streets and adjacent domestic or commercial properties that carries pollutants of various kinds into the sewer systems and receiving waters.

V

Variances Waivers granted to existing property owners if the owner can demonstrate severe economic hardship or unique circumstances that make it impossible to meet some or all of the development (e.g., buffers) requirements.

Vegetative buffer zones Undisturbed or planted vegetated areas that surround a development, land disturbance activity, or border an intermittent stream or permanent water body.

Volatile Organic Compounds (VOCs) Hydrocarbon compounds that exist in the ambient air. VOCs contribute to the formation of smog and/or are toxic. VOCs often have an odor.

Some examples of VOCs are gasoline, alcohol, and solvents used in paints.

W

Wastewater The spent or used water from a home, community, farm, or industry that contains dissolved or suspended matter.

Water pollution The presence in water of enough harmful or objectionable material to damage the water's quality.

Water quality criteria Levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water quality standards State-adopted and EPA-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water table The level of groundwater.

Watershed The land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point.

Watershed area A topographic area within a line drawn connecting the highest points uphill of a drinking water intake into which overland flow drains.

Watershed-based zoning An alternative zoning technique, whereby the intensity of development within a watershed or subwatershed is at least partially based on the ultimate percentage of impervious cover, and the desired level of stream protection.

Wetlands An area that is saturated by surface or ground water with vegetation adapted for life under those soil conditions, as swamps, bogs, fens, marshes, and estuaries.

Windthrow The uprooting and felling of trees by strong gusts of wind. Also, patches of trees that have been so felled.

Appendix A – Costs of Urban and Community Forestry Management

Table A-1. Mississippi Main Street Association statistical highlights for member communities (2003).

City	Start Date	Busi-nesses Created	Busi-nesses Expanded	Buildings Improved	Jobs Created	Private Dollars Invested	Public Dollars Invested
Aberdeen	1993	64	11	51	154	$10,259,162	$7,817,716
Batesville	1999	22	3	2	91	$92,093	$136,076
Bay St. Louis		33		20	120	$830,011	$1,174,894
Biloxi	1991	38	4	18	4,615	$664,068,450	$2,510,100
Booneville	1997	49	9	12	145	$412,550	$139,975
Canton	1990	116	14	51	488	$11,796,384	$8,282,980
Cleveland	1990	91	2	37	464	$6,828,550	$1,445,000
Columbia	1992	62	6	29	157	$626,030	$133,470
Columbus	1985	143	8	47	669	$22,689,213	$3,982,347
Corinth	1987	100	5	95	200	$11,273,742	$900,000
D'Lo/ Menden-hall		7			7	$40,600	$16,000
Fondren/ Jackson	1999	23	8	43	151	$16,136,000	$200,000
Greenville	1995	115	17	47	869	$45,495,732	$6,708,244
Green-wood	1995	47	3	21	196	$36,400,000	$2,200,000

Table A-1. Mississippi Main Street Association statistical highlights for member communities (2003) (continued).

City	Start Date	Busi-nesses Created	Busi-nesses Expanded	Buildings Improved	Jobs Created	Private Dollars Invested	Public Dollars Invested
Grenada	1994	50	6	24	86	$2,753,720	$401,870
Hatties-burg	2000	33	2	1	236	$13,089,350	$14,033,163
Hernando	1997	40	9	5	127	$14,060,050	$8,178,500
Kosciusko	1999	33	1	33	108	$5,557,322	$514,672
Leland	2001	3	2		8	$123,000	$22,942
Lexington	2001	8	1		10	$104,785	$25,300
Long Beach		4			15	$50,000	$12,000
Magee	2001	11	1	2	18	$785,000	
McComb	1990	50	2	1	177	$2,206,200	$1,282,404
Meridian	1985	274	15	258	2,635	$65,038,848	$4,693,598
Natchez	1998	33	1	13	73	$2,336,790	$827,083
New Albany	1996	48	5	29	83	$2,172,540	$742,857
Ocean Springs	1990	130	23	129	386	$66,774,868	$3,124,000
Okolona	2000	12			6	$170,015	$143,236
Olive Branch	1999	15	2	1	28	$212,200	$78,928
Pascagoula	2000	45	1		87	$600	$23,319
Philadel-phia	2000	22	5	53	87	$1,150,054	$74,500
Picayune	1996	47	4	7	73	$1,736,998	$65,490

Table A-1. Mississippi Main Street Association statistical highlights for member communities (2003) (continued).

City	Start Date	Busi-nesses Created	Busi-nesses Expanded	Buildings Improved	Jobs Created	Private Dollars Invested	Public Dollars Invested
Port Gibson	1990	47	3	47	155	$1,068,200	$3,659,045
Ripley	2001	24	29	5	197	$4,301,900	$734,900
Senatobia	1992	93	6	30	168	$471,400	$4,477,000
Southaven	2001	91			227	$1,436,481	$2,636,601
Tunica	2000	10	1	5	21	$1,675,000	$5,419,700
Tupelo	1991	221	4	101	677	$53,798,974	$41,599,376
Vicksburg	1984	60	2	17	2,424	$54,031,325	$4,516,760
West Point	1984	80		101	307	$46,254,954	$7,106,520
Yazoo City	1990	15		49	94	$1,094,000	$8,085,000
TOTALS		**2409**	**215**	**1384**	**16,839**	**$1,169,403,091**	**$148,125,566**

Appendix B – Effective Urban and Community Forestry Management

Table B-1. Maps and data sets used for the CRI.

Natural Resource Inventory

1. Base Map
   a. Study map boundary—site, town, watershed region.
   b. Orientation elements—major roads, water bodies.
   c. USGS quadrangle maps.
   d. Aerials (Digital Orthophoto Quads—DOQs).
2. Land Cover—a single data layer with much information associated.
3. Soils—another single data layer with lots of info attached including wetland and prime agricultural soils.
4. Water Resources
   a. Watershed boundaries (major, regional, and local).
   b. Public supply areas.
   c. Surface water.
   d. Wells.
   e. Water quality.
5. Unique and Fragile Resources
   a. Natural diversity database.
   b. Swamps, marshes, prairies and other rare ecosystems.
   c. Other important information that may be available locally such as endangered plant and animal communities.
6. Committed Open Space—a single data layer that includes state, municipal, and private lands. This information should be supplemented with local information.

Social Resource Inventory

1. Community Infrastructure
   a. Roads.
   b. Railroads.
   c. Airports.

Table B-1. Maps and data sets used for the CRI (continued).

   d. Sewer Service Areas.
   e. Other important information that may be available locally include: parcels, community facilities, utility lines.
2. Regulated Lands
   a. Floodplains (from FEMA).
   b. Wetlands (derived from soils data).
   c. Zoning (available from your town planning department).
3. Cultural Resources
   a. Scenic Areas.
   b. Recreation Resources.
   c. Archeological Sites.
   d. Historical Resources.

Economic Resource Inventory

1. Population Characteristics
2. Physical/Natural Areas
3. Institutional Resources
4. Capital Resources

Table B-2. Tree inventory description and decision guide.

What is a tree inventory?

A tree inventory is the gathering of accurate information on the health and diversity of the community forest. How many street trees are there? What kind? In what condition are they? You cannot manage the community forest effectively unless you know its condition. Tree inventories are an essential tool of good management.

Why should my community do a tree inventory?

There are many good reasons for doing a tree inventory in your community. 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 (that could cost the community in liability damages) or areas that are bare of trees, this suggests that

Table B-2. Tree inventory description and decision guide (continued).

a program incorporating tree planting is badly needed.

≈ Prioritize maintenance schedules to reduce the potential liability that results from hazardous trees. It also streamlines the efficiency of street crews and facilitates long-term budgeting.

≈ Educate residents about the benefits of a healthy, well-managed community forest, and to 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.

What information should be collected during an inventory?

Only data that will be put to use should be collected. Your community must determine what objectives it wishes to achieve prior to conducting an inventory. Bear in mind that information translates into expense: the more data gathered on each tree, the greater the cost of the inventory. Generally however, information on the following is collected:

≈ Tree species: To avoid costly mistakes, record the scientific names of trees. Common names or codes can also be included, if desired, but care should be taken to maintain consistency.

≈ Tree size: DBH (diameter at breast height—4.5 feet above ground), height, and crown spread.

≈ Condition: Indicate what maintenance procedure is needed. Does the tree need corrective pruning? Does it require removal? It is important to note that if the tree is deemed to be a hazard to the public and removal is mandatory, rather than record "hazardous," it is prudent to record "removal."

≈ Damage: Record insect infestations, injuries and diseases by indicating the precise procedure necessary. For example, rather than describe lightning damage, indicate the need for pruning or removal. It is prudent to have a skilled tree crew correct the problem as soon as possible.

≈ Management/maintenance: Record need to fertilize, apply fungicides/insecticides, prune, repair curbs and/or sidewalk damage inflicted by roots, remove stump/tree, or plant in an empty planting site. Do so in order to schedule maintenance work, allocate equipment, and prepare budgets.

≈ Site characteristics: How much space is available for the root system? What is the condition and health of the soil in the planting space? The proximity of overhead/underground utilities and tall buildings? The potential for road salt/traffic damage? Is it zoned commercial?

Table B-2. Tree inventory description and decision guide (continued).

- Planting spaces: Research suggests that a community should give highest priority to planting trees on streets where yard trees are few. Identify planting spaces to encourage the planting of bare areas.
- Historic/Distinctive Trees and Groves: Special trees require more intensive management. (Note: Trees of this nature may also serve to justify the inventory itself if the community is hesitant to undertake a management program).

What type of inventory should my community do?

There are many different types of inventories and you should select an inventory type only when you know precisely what you want to accomplish. Data gathered on your community's trees must have practical value. To guarantee that your tree management program will be effective today and useful tomorrow, you must match an appropriate inventory to your objectives. The most common types include:

- Specific Problem Inventory: Gathers data about a specific problem or condition for work contracts or work schedules. For example, a survey of hazard trees or the extent of Dutch elm disease are specific problem inventories. Note that every community should conduct a yearly survey of hazardous trees. (Marking hazardous trees is not recommended since doing so may increase liability.)
- Partial Inventory: Gathers data from a sample (or samples) and information is extrapolated to apply to the whole forest. Survey is easily completed by one or more observers with data recorders walking or driving in as little as 4 weeks, depending on the scope of the inventory (i.e., street trees or entire watershed).
- Complete Inventory: Surveys the entire tree population but it is time consuming and expensive.
- Cover-type Survey: Information is gathered by at least partial use of aerial photographs and sometimes with a geographical information system. This type of survey is used increasingly in urban areas to examine the entire tree population to plan long-term land use. It is especially useful in intensively managed areas such as parks and campuses, but it can be expensive and produces detail that few community tree management programs can use effectively.

How should the inventory be done?

The tree inventory may be done by professionals or volunteers, but, in either case, all crews, regardless of experience, require training before and during the inventory. (Note: It is advisable that the municipal tree warden or

Table B-2. Tree inventory description and decision guide (continued).

another qualified professional assist or lead the tree inventory process. It is also advisable that a person trained in hazard tree assessment review all trees surveyed and assess them for hazardous condition).

Individuals working alone tend to be more productive, but crews attract attention, and this fact may be exploited to good advantage: professionals who carry brochures about the tree management program and the inventory or questionnaires about willingness to fund tree management programs can educate community residents. Crews should wear uniforms, if possible, and carry identification cards as well as the tree warden or other qualified professional's phone number. Where crime is a problem, two or more people must work together for safety.

When should the inventory be done?

Summer months are more conducive to partial inventories, due to heat and humidity, and students are often available to help. Favorable weather in the fall and spring makes inventory work more pleasant and allows more area to be inventoried. On the other hand, winter conditions allow crews to observe trees for hazardous limbs and dead wood. Professional foresters often choose to conduct inventories in the winter, unless crown cover is being recorded.

How should the inventory be updated?

Tree populations undergo constant change, and, as an inventory ages, it becomes less accurate and useful. No inventory will provide information that is useful beyond five or 10 years. However, any inventory data can be useful because it provides a baseline and incentive for initiating a community tree management program. Consider the damage a single storm can do. Hurricane winds can render an inventory obsolete overnight. The ideal way to keep the inventory current is to make use of specially designed computer programs that provide easy and logical locations for data entry specific to tree inventories. Good programs also allow you to easily query data and produce reports, graphs, and tables and perform statistical analyses.

Hazardous trees

Stress conditions exist in the community forest severely affecting the health of individual trees. Trees that pose a hazard to public safety need to be detected and treated by removal or pruning as soon as possible. It is prudent that the municipal tree warden frequently assess trees for hazardous conditions.

Table B-3. Tree management cost worksheet for urban and community trees.

Tree Management Activity				
Tree Conservation	**# Units**	**Unit Cost**	**Total Cost**	**Notes**
Project Planning		$	$	
Tree Inventory, Mapping, and Evaluation		$	$	
Other		$	$	
Tree Protection[1]	**# Units**	**Unit Cost**	**Total Cost**	**Notes**
Project Planning		$	$	
Establishing the Tree Protection Zone		$	$	
Fencing		$	$	
Fence Posts		$	$	
Signage		$	$	
Worker Education		$	$	
Inspection and Monitoring		$	$	
Pre- and Post-Construction Maintenance		$	$	
Other		$	$	
Tree Establishment	**# Units**	**Unit Cost**	**Total Cost**	**Notes**
Tree Selection		$	$	
Site Selection		$	$	
Site Preparation		$	$	
Tree Purchase and Planting		$	$	
Mulch		$	$	
Tree Trunk Protectors		$	$	

Table B-3. Tree management cost worksheet for urban and community trees (continued).

Tree Establishment (continued)	# Units	Unit Cost	Total Cost	Notes
Root Barriers		$	$	
Structural Soil		$	$	
Other		$	$	
New Tree Maintenance[2,3]	**# Units**	**Unit Cost**	**Total Cost**	**Notes**
Mulch		$	$	
Pruning		$	$	
Watering (5 times/mo for 3 months)		$	$	
Other		$	$	
Established Tree Maintenance[4]	**# Units**	**Unit Cost**	**Total Cost**	**Notes**
Mulch (annually)		$	$	
Inspection (every 1 to 5 years)		$	$	
Pruning (every 3 to 5 years)		$	$	
Optional	**# Units**	**Unit Cost**	**Total Cost**	**Notes**
Hazardous Tree Removal		$	$	
Soil Sampling (prior to fertilization)		$	$	
Fertilization (as necessary)		$	$	
Vertical Mulching (as necessary)		$	$	
Irrigation (during droughts)		$	$	
Pest Management (as necessary)		$	$	
Cabling/Bracing (as necessary)		$	$	

Table B-3. Tree management cost worksheet for urban and community trees (continued).

Optional (continued)	# Units	Unit Cost	Total Cost	Notes
Lightning Protection (as necessary)		$	$	
Root Barriers (as necessary)		$	$	
Other Tree Removal (at end of service life)		$	$	
Other		$	$	

[1]Additional tree protection materials may be required, such as root padding, trunk wraps, or additional fencing, posts, and signs.

[2]Annual maintenance for new trees during the first 3 years after planting.

[3]Inspect while trees are being mulched, pruned, and watered.

[4]Routine and periodic maintenance for established trees.

Table B-4. Long-term cost saving strategies for urban and community forests.

1. Provide and maintain adequate growing space for trees.
2. Select good quality trees.
3. Plant trees correctly.
4. Water newly planted trees during the establishment period, the first 3 years after planting.
5. Mulch new and established trees annually.
6. Use leaf litter and wood chip mulch available for free from municipal or private sources.
7. Prune new trees early to develop a strong, healthy branch structure.
8. Prune established trees properly and regularly to maintain a safe and healthy condition.
9. Top trees only as a last resort (e.g., mistletoe infestation), or as a growth management tool.
10. Maintain soil and root health to maintain tree health.
11. Protect a tree's roots, trunk, and crown daily throughout its life.
12. Actively protect trees on building construction and utility installation and repair sites.

Table B-5. Example goals and ordinance provisions for urban and community forest programs.

Goal 1. Establish and maintain maximum tree cover

Ordinance provisions:

a. Designate administrative responsibilities.
b. Develop a comprehensive management plan.
c. Resolution of conflicts between trees and structures.
d. Planting requirements.
e. Permit required for activities that may damage city owned trees.
f. Permit required for activities that may damage protected private trees.
g. Conservation of forest and woodland resources during development.

Goal 2. Maintain trees in a healthy condition through good cultural practices.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Develop a comprehensive management plan.
c. Resolution of conflicts between trees and structures.
d. Help for citizens performing tree maintenance.
e. Topping prohibited.
f. Planting requirements.
g. Harming public trees forbidden.
h. Situations which are declared to be public nuisances.
i. Abatement of hazards and public nuisances.
j. Licensing of private tree care firms.
k. Permit required for activities that may damage city owned trees.
l. Permit required for activities that may damage protected private trees.
m. Conservation of forest and woodland resources during development.

Table B-5. Example goals and ordinance provisions for urban and community forest programs (continued).

Goal 3. Establish and maintain an optimal level of age and species diversity.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Develop a comprehensive management plan.
c. Planting requirements.
d. Conservation of forest and woodland resources during development.

Goal 4. Promote conservation of tree resources.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Develop a comprehensive management plan.
c. Resolution of conflicts between trees and structures.
d. Planting requirements.
e. Permit required for activities that may damage city owned trees.
f. Permit required for activities that may damage protected private trees.
g. Conservation of forest and woodland resources during development.

Goal 5. Select, situate, and maintain street trees appropriately to maximize benefits.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Develop a comprehensive management plan.
c. Responsibilities of property owners.
d. Permit required for planting trees in the public right-of-way.
e. Planting requirements.
f. Permit required for activities that may damage city owned trees.

Table B-5. Example goals and ordinance provisions for urban and community forest programs (continued).

Goal 6. Centralize tree management under a person or persons with the necessary experience.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Establish a tree board or commission.
c. Specify cooperation between departments and agencies.
d. Develop a comprehensive management plan.

Goal 7. Promote efficient and cost-effective management of the urban forest.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Specify cooperation between departments and agencies.
c. Develop a comprehensive management plan.

Goal 8. Foster community support for the local urban forestry program and encourage good tree management on privately-owned properties.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Establish a tree board or commission with tree warden.
c. Help for citizens performing tree maintenance.

Goal 9. Facilitate the resolution of tree-related conflicts between citizens with tree board.

Ordinance provisions:

a. Designate administrative responsibilities.
b. Procedures to be followed in resolving tree disputes.
c. Standards for resolution of tree disputes.
d. Apportionment of tree dispute resolution costs.
e. Recording for notification of future owners.
f. Enforcement of tree dispute resolutions.

Table B-6. Methods to monitor the effectiveness of urban and community forest programs*.

1. **Sampling from populations.** In many cases, it will be more efficient to evaluate a sample population under study (i.e., trees, parking lots, homeowners) than to evaluate an entire population.
2. **Photogrammetry and remote sensing techniques**. Using stock aerial photographs or other aerial imagery, photogrammetric techniques can be used to assess tree canopy cover quickly and cost-effectively.
3. **Ground survey**. For many applications, the ground survey is still the simplest and most accurate means for collecting detailed data on the urban forest.
4. **Photo points**. Photographs taken from the ground or the air can provide graphic and obvious evidence of changes in tree condition and cover.
5. **Record keeping and analysis**. Well-maintained records and databases can be analyzed to provide a wealth of information on ordinance performance.
6. **Public polling**. The public is an integral part of the urban forest ecosystem.

*In-depth descriptions of each method are available at: www.isa-arbor.com/publications/ordinance.aspx

Appendix C – Urban and Community Stream Protection Strategies

Table C-1. Model ordinance for stream buffers.

Buffer Model Ordinance

This ordinance focuses primarily on stream buffers. Communities creating coastal buffers may wish to incorporate additional features. For an example of a coastal buffer ordinance, see the Rhode Island Ordinance at www.stormwatercenter.net/Model%20Ordinances/rhode_island_buffer_ordinance.htm

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Section I. Background

Whereas, buffers adjacent to stream systems and coastal areas provide numerous environmental protection and resource management benefits which can include:

a) restoring and maintaining the chemical, physical, and biological integrity of the water resources,
b) removing pollutants delivered in urban stormwater,
c) reducing erosion and controlling sedimentation,
d) stabilizing stream banks,
e) providing infiltration of stormwater runoff,
f) maintaining base flow of streams,
g) contributing organic matter that is a source of food and energy for an aquatic ecosystem,
h) providing tree canopy to shade streams and promote desirable aquatic organisms,
This benefit applies primarily to forested buffer systems. In some communities, such as in prairie settings, the native vegetation may not be forest. See an example ordinance from Napa, California at www.stormwatercenter.net/Model%20Ordinances/napa_buffer_ordinance.htm) providing riparian wildlife habitat, and
j) furnishing scenic value and recreational opportunity.

It is the desire of the (Natural Resources or Planning Agency) to protect and maintain native vegetation in riparian and wetland areas by implementing specifications for the establishment, protection, and maintenance of vegetation along all stream systems and/or coastal zones within our jurisdictional authority.

Table C-1. Model ordinance for stream buffers (continued).

Section II. Intent

The purpose of this ordinance is to establish minimal acceptable requirements for the design of buffers to protect streams, wetlands and floodplains of (Jurisdiction); water quality of watercourses, reservoirs, lakes, and other significant water resources within (Jurisdiction); (Jurisdiction's) riparian and aquatic ecosystems; and to provide for environmentally sound use of (Jurisdiction's) land resources.

Section III. Definitions

Active Channel: The area of the stream channel subject to frequent flows (approximately once per one and a half years), and includes the portion of the channel below where the floodplain flattens.

Best Management Practices (BMPs): Conservation practices or management measures which control soil loss and reduce water quality degradation caused by nutrients, animal wastes, toxins, sediment, and runoff.

Buffer: A vegetated area, including trees, shrubs and herbaceous vegetation, which exists or is established to protect a stream system, lake, reservoir, or coastal estuarine area. Alteration of this natural area is strictly limited.

Development: 1) The improvement of property for any purpose involving building; 2) Subdivision, or the division of a tract or parcel of land into 2 or more parcels; 3) the combination of any 2 or more lots, tracts, or parcels of property for any purpose; 4) the preparation of land for any of the above purposes.

Non-Tidal Wetland: Those areas not influenced by tidal fluctuations that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

The definition of "non-tidal wetland" is adapted from the definition of "wetland" used by the USEPA and the U.S. Army Corps of Engineers. Other definitions will also be acceptable. See the Croton-on-Hudson Wetlands and Watercourses ordinance for an example.

Nonpoint Source Pollution: Pollution which is generated by various land use activities rather than from an identifiable or discrete source, and is conveyed to waterways through natural processes, such as rainfall, storm runoff, or ground water seepage rather than direct discharge.

One Hundred Year Floodplain: The area of land adjacent to a stream subject to inundation during a storm event that has a recurrence interval of one hundred (100) years.

Pollution: Any contamination or alteration of the physical, chemical, or biological properties of any

Table C-1. Model ordinance for stream buffers (continued).

waters that will render the waters harmful or detrimental to: public health, safety, or welfare; domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses; livestock, wild animals, or birds; and fish or other aquatic life.

Stream Channel: Part of a water course either naturally or artificially created which contains an intermittent or perennial base flow of groundwater origin. Base flows of groundwater origin can be distinguished by any of the following physical indicators:

1) hydrophytic vegetation, hydric soil, or other hydrologic indicators in the area(s) where groundwater, enters the stream channel, in the vicinity of the stream headwaters, channel bed or channel banks
2) flowing water not directly related to a storm event, and
3) historical records of a local high groundwater table, such as well and stream gauge records.

Stream Order: A classification system for streams based on stream hierarchy. The smaller the stream, the lower its numerical classification. For example, a first-order stream does not have tributaries and normally originates from springs and/or seeps. At the confluence of two first-order streams, a second-order stream begins, and so on. (See Figure 1)

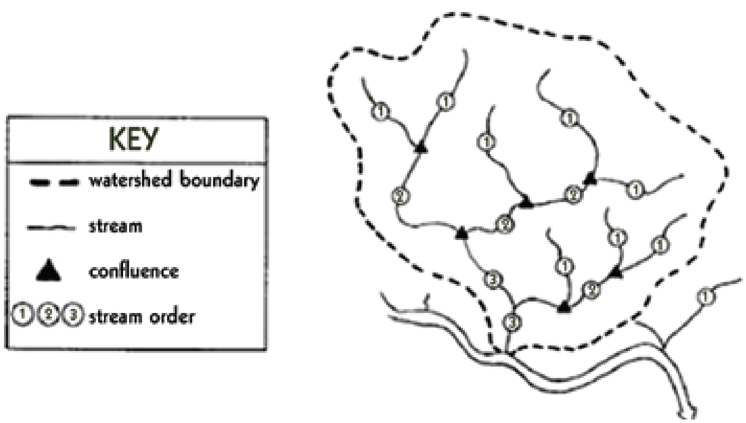

Figure 1: Stream order (Source: Schueler, 1995).

Stream System: A stream channel together with one or both of the following:
1) 100-year floodplain and/or
2) hydrologically-related non-tidal wetlands.

Streams: Perennial and intermittent watercourses identified through site inspection and USGS maps.

Table C-1. Model ordinance for stream buffers (continued).

Perennial streams are those which are depicted on a USGS map with a solid blue line. Intermittent streams are those which are depicted on a USGS map with a dotted blue line.
Defining the term "stream" is perhaps the most contentious issue in the definition of stream buffers. This term determines the origin, and the length of the stream buffer. While some jurisdictions restrict the buffer to perennial or "blue line" streams, others include both perennial and intermittent streams in the stream buffer program. Some communities do not rely on USGS maps, and instead prepare local maps of all stream systems that require a buffer.
Water Pollution Hazard: A land use or activity that causes a relatively high risk of potential water pollution.

Section IV. Applications
A) This ordinance shall apply to all proposed development except for that development which meets waiver or variance criteria as outlined in Section IX of this regulation.

B) This ordinance shall apply to all timber harvesting activities, except those timber harvesting operations which are implementing a forest management plan which has been deemed to be in compliance with regulations of the buffer ordinance and has received approval from (state forestry agency).

C) This ordinance shall apply to all surface mining operations except that the design standards shall not apply to active surface mining operations which are operating in compliance with an approved (state or federal agency) surface mining permit.

D) The ordinance shall not apply to agricultural operations covered by an approved NRCS conservation plan that includes the application of best management practices.
Communities should carefully consider whether or not to exempt agricultural operations from the buffer ordinance, because buffer regulations may take land out of production and impose a financial burden on family farms. Many communities exempt agricultural operations if they have an approved NRCS conservation plan. In some regions, agricultural buffers may be funded through the Conservation Reserve Program (CRP). Consult the Conservation Technology Information Center (CTIC) at www.ctic.perdue.edu.
Livestock operations near and around streams may be regulated by communities. Livestock can significantly degrade the stream system and accelerate streambank erosion. The King County Livestock Management Ordinance is one example of a local livestock ordinance. For more information,

Table C-1. Model ordinance for stream buffers (continued).

contact the King County Department of Development and Environmental Services at (206) 296-6602.

E) Except as provided in Section IX, this ordinance shall apply to all parcels of land, structures, and activities which are causing or contributing to:

1) pollution, including non-point pollution, of the waters of the jurisdiction adopting this ordinance,
2) erosion or sedimentation of stream channels, and
3) degradation of aquatic or riparian habitat.

Section V. Plan Requirements

A) In accordance with Section IV of this ordinance, a plan approved by the appropriate agency is required for all development, forest harvesting operations, surface mining operations, and agricultural operations.

B) The plan shall set forth an informative, conceptual and schematic representation of the proposed activity by means of maps, graphs, charts, or other written or drawn documents so as to give the agency an opportunity to make a reasonably informed decision regarding the proposed activity.

C) The plan shall contain the following information:

The ordinance can identify the scale of maps to be included with the analyses in items 2) through 7). A 1"=50' to 1"=100' scale will generally provide sufficient detail.

1) a location or vicinity map,
2) field delineated and surveyed streams, springs, seeps, bodies of water, and wetlands (include a minimum of two hundred (200) feet into adjacent properties),
3) field delineated and surveyed forest buffers,
4) limits of the ultimate one hundred (100) year floodplain,
   The limits of the ultimate floodplain (i.e., the floodplain under "built-out" conditions) may not be available in all locations.
5) hydric soils mapped in accordance with the NRCS soil survey of the site area,
6) steep slopes greater than fifteen (15) percent for areas adjacent to and within two hundred

Table C-1. Model ordinance for stream buffers (continued).

(200) feet of streams, wetlands, or other water bodies, and
The ordinance may also explicitly define how slopes are measured. For example, the buffer may be divided into sections of a specific width (e.g., 25 feet) and the slope for each segment reported. Alternatively, slopes can be reported in segments divided by breaks in slope.

7) a narrative of the species and distribution of existing vegetation within the buffer.

D) The buffer plan shall be submitted in conjunction with the required grading plan for any development, and the forest buffer should be clearly delineated on the final grading plan.

E) Permanent boundary markers, in the form of signage approved by (Natural Resources or Planning Agency), shall be installed prior to final approval of the required clearing and grading plan. Signs shall be placed at the edge of the Middle Zone (See Section VI.E).

Section VI. Design Standards for Forest Buffers

A) A forest buffer for a stream system shall consist of a forested strip of land extending along both sides of a stream and its adjacent wetlands, floodplains, or slopes. The forest buffer width shall be adjusted to include contiguous sensitive areas, such as steep slopes or erodible soils, where development or disturbance may adversely affect water quality, streams, wetlands, or other water bodies.

B) The forest buffer shall begin at the edge of the stream bank of the active channel.

C) The required width for all forest buffers (i.e., the base width) shall be a minimum of one hundred feet, with the requirement to expand the buffer depending on: 1) stream order; 2) percent slope; 3) 100-year floodplain; and 4) wetlands or critical areas.
The width of the stream buffer varies from 25 feet to up to 200 feet in ordinances throughout the United States. The width chosen by a jurisdiction will depend on the sensitivity and characteristics of the resource being protected and political realities in the community.

1) In third-order and higher streams, add 25 feet to the base width.
2) Forest Buffer width shall be modified if there are steep slopes which are within a close proximity to the stream and drain into the stream system. In those cases, the forest buffer width can be adjusted.

Several methods may be used to adjust buffer width for steep slopes. Two examples include:

Table C-1. Model ordinance for stream buffers (continued).

Method A

Percent Slope	Width of Buffer
15 to 17%	add 10 feet
18 to 20%	add 30 feet
21 to 23%	add 50 feet
24 to 25%	add 60 feet

Method B

	Type of Stream Use	
Percent Slope	Water Contact Recreational Use	Sensitive Stream Habitat
0 to 14%	no change	add 50 feet
15 to 25%	add 25 feet	add 75 feet
Greater than 25%	add 50 feet	add 100 feet

3) Forest buffers shall be extended to encompass the entire 100-year floodplain and a zone with minimum width of 25 feet beyond the edge of the floodplain.
4) When wetland or critical areas extend beyond the edge of the required buffer width, the buffer shall be adjusted so that the buffer consists of the extent of the wetland plus a 25 foot zone extending beyond the wetland edge.

D) Water pollution hazards - The following land uses and/or activities are designated as potential water pollution hazards, and must be set back from any stream or water body by the distance indicated below:

1) storage of hazardous substances (150 feet),
2) above or below ground petroleum storage facilities (150 feet) ,
3) drain fields from on-site sewage disposal and treatment system (i.e., septic systems—100 feet),
4) raised septic systems (250 feet),

Table C-1. Model ordinance for stream buffers (continued).

5) solid waste landfills or junk yards (300 feet),
6) confined animal feedlot operations (250 feet),
7) subsurface discharges from a wastewater treatment plant (100 feet), and
8) land application of biosolids (100 feet).

For surface water supplies, the setbacks should be doubled.

A community should carefully consider which activities or land uses should be designated as potential water pollution hazards. The list of potential hazards shown above is not exhaustive, and others may need to be added depending on the major pollutants of concern and the uses of water.

E) The forest buffer shall be composed of three distinct zones, with each zone having its own set of allowable uses and vegetative targets as specified in this ordinance. (See Figure 2).

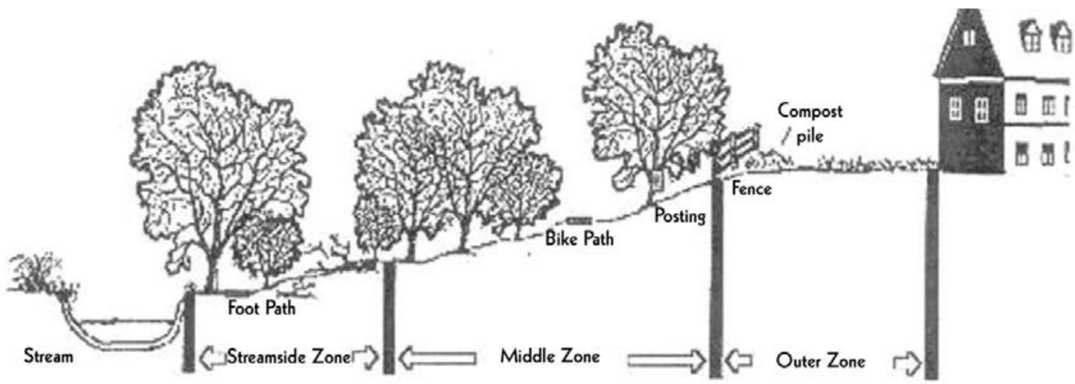

Figure 2: Three-zone buffer system (Adapted from Welsch, 1991).

Although a three-zone buffer system is highly recommended, the widths and specific uses allowed in each zone may vary between jurisdictions.

1) Zone 1–Streamside Zone
   a) The function of the streamside zone is to protect the physical and ecological integrity of the stream ecosystem.

Table C-1. Model ordinance for stream buffers (continued).

b) The streamside zone will begin at the edge of the stream bank of the active channel and extend a minimum of 25 feet from the top of the bank.

c) Allowable uses within this zone are highly restricted to:

i) flood control structures,

ii) utility rights of way,

iii) footpaths, and

iv) road crossings, where permitted.

d) The vegetative target for the streamside zone is undisturbed native vegetation.

This ordinance assumes that native vegetation in the stream corridor is forest. In some regions of the United States, other vegetation such as prairie may be native. See the Napa, California buffer ordinance at www.stormwatercenter.net/Model%20Ordinances/napa_buffer_ordinance.htm for an example of a stream buffer ordinance that protects non-forested systems.

2) Zone 2—Middle Zone

a) The function of the middle zone is to protect key components of the stream and to provide distance between upland development and the streamside zone.

b) The middle zone will begin at the outer edge of the streamside zone and extend a minimum of 50 plus any additional buffer width as specified in Section VI C.

c) Allowable uses within the middle zone are restricted to:

i) biking or hiking paths,

ii) stormwater management facilities, with the approval of (Local agency responsible for stormwater),

iii) recreational uses as approved by (Planning Agency), and

iv) limited tree clearing with approval from (Forestry agency or Planning Agency).

d) The vegetative target for the middle zone is mature native vegetation adapted to the region.

3) Zone 3—Outer Zone

a) The function of the outer zone is to prevent encroachment into the forest buffer and to filter runoff from residential and commercial development.

b) The outer zone will begin at the outward edge of the middle zone and provide a minimum width of 25 feet between Zone 2 and the nearest permanent structure.

c) There shall be no septic systems, permanent structures, or impervious cover, with the exception of paths within the outer zone.

Table C-1. Model ordinance for stream buffers (continued).

d) The vegetative target for the outer zone may vary, although the planting of native vegetation should be encouraged to increase the total width of the buffer.

Section VII. Buffer Management and Maintenance

A) The forest buffer, including wetlands and floodplains, shall be managed to enhance and maximize the unique value of these resources. Management includes specific limitations on alteration of the natural conditions of these resources. The following practices and activities are restricted within Zones 1 and 2 of the forest buffer, except with approval by (Forestry, Planning, or Natural Resources Agency):

1) clearing of existing vegetation,
2) soil disturbance by grading, stripping, or other practices,
3) filling or dumping.,
4) draining by ditches, underdrains, or other systems,
5) using, storing, or applying pesticides, except for the spot spraying of noxious weeds or non-native species consistent with recommendations of (Forestry Agency),
6) housing, grazing, or other maintenance of livestock, and
7) storing or operating motorized vehicles, except for maintenance and emergency use approved by (Forestry, Planning, or Natural Resources Agency)

B) The following structures, practices, and activities are permitted in the forest buffer, with specific design or maintenance features, subject to the review of (Forestry, Planning, or Natural Resources Agency):

1) Roads, bridges, paths, and utilities:
   a) an analysis needs to be conducted to ensure that no economically feasible alternative is available,
   b) the right of way should be the minimum width needed to allow for maintenance access and installation,
   c) the angle of the crossing shall be perpendicular to the stream or buffer in order to minimize clearing requirements, and
   d) the minimum number of road crossings should be used within each subdivision, and no more than one fairway crossing is allowed for every 1,000 feet of buffer.

Table C-1. Model ordinance for stream buffers (continued).

2) Stormwater management:
   e) an analysis needs to be conducted to ensure that no economically feasible alternative is available, and that the project is either necessary for flood control, or significantly improves the water quality or habitat in the stream,
   f) in new developments, on-site and non-structural alternatives will be preferred over larger facilities within the stream buffer,
   g) when constructing stormwater management facilities (i.e., BMPs), the area cleared will be limited to the area required for construction and adequate maintenance access, as outlined in the most recent edition of (Refer to Stormwater Manual), and

Rather than place specific stormwater BMP design criteria in an ordinance, it is often preferable to reference a manual. Therefore, specific design information can change over time without going through the formal process needed to change ordinance language. The Maryland Stormwater Design Manual, is one example of an up-to-date stormwater design manual. For more information, go to www.mde.state.md.us. Under topics, choose "Stormwater Design Manual."

   h) material dredged or otherwise removed from a BMP shall be stored outside the buffer.
3) Stream restoration projects, facilities, and activities approved by (Forestry, Planning, or Natural Resources Agency) are permitted within the forest buffer.
4) Water quality monitoring and stream gauging are permitted within the forest buffer, as approved by (Forestry, Planning or Natural Resources Agency).
5) Individual trees within the forest buffer may be removed which are in danger of falling, causing damage to dwellings or other structures, or causing blockage of the stream.
6) Other timber cutting techniques approved by the agency may be undertaken within the forest buffer under the advice and guidance of (State or Federal Forestry Agency), if necessary to preserve the forest from extensive pest infestation, disease infestation, or threat from fire.

C) All plats prepared for recording and all right-of-way plats shall clearly:
1) show the extent of any forest buffer on the subject property by metes and bounds,
2) label the forest buffer,
3) provide a note to reference any forest buffer stating: "There shall be no clearing, grading, construction or disturbance of vegetation except as permitted by the agency," and
4) provide a note to reference any protective covenants governing all forest buffers areas stating: "Any forest buffer shown hereon is subject to protective covenants which may be found

Table C-1. Model ordinance for stream buffers (continued).

in the land records and which restrict disturbance and use of these areas."

D) All forest buffer areas shall be maintained through a declaration of protective covenant, which is required to be submitted for approval by (Planning Board or Agency). The covenant shall be recorded in the land records and shall run with the land and continue in perpetuity.
This protective covenant can be kept either by the local government agency responsible for management of environmental resources, or by an approved non-profit organization. An example conservation easement is included later in this section.

E) All lease agreements must contain a notation regarding the presence and location of protective covenants for forest buffer areas, and which shall contain information on the management and maintenance requirements for the forest buffer for the new property owner.

F) An offer of dedication of a forest buffer area to the agency shall not be interpreted to mean that this automatically conveys to the general public the right of access to this area.

G) (Responsible Individual or Group) shall inspect the buffer annually and immediately following severe storms for evidence of sediment deposition, erosion, or concentrated flow channels and corrective actions taken to ensure the integrity and functions of the forest buffer.
A local ordinance will need to designate the individual or group responsible for buffer maintenance. Often, the responsible party will be identified in any protective covenants associated with the property.

H) Forest buffer areas may be allowed to grow into their vegetative target state naturally, but methods to enhance the successional process such as active reforestation may be used when deemed necessary by (Natural Resources or Forestry Agency) to ensure the preservation and propagation of the buffer area. Forest buffer areas may also be enhanced through reforestation or other growth techniques as a form of mitigation for achieving buffer preservation requirements.
Explicit forestry management criteria are often included in a forestry or natural resources conservation ordinance. An example forest conservation ordinance from Frederick County, Maryland is included in the Miscellaneous portion of this site at www.stormwatercenter.net/Model%20Ordinances/misc__forest_conservation.htm.

Table C-1. Model ordinance for stream buffers (continued).

Section VIII. Enforcement Procedures

A) (Director of Responsible Agency) is authorized and empowered to enforce requirements of this ordinance in accordance with procedures of this section.

B) If, upon inspection or investigation, the director or his/her designee is of the opinion that any person has violated any provision of this ordinance, he/she shall with reasonable promptness issue a correction notice to the person. Each such notice shall be in writing and shall describe the nature of the violation, including a reference to the provision within this ordinance which has been violated. In addition, the notice shall set a reasonable time for the abatement and correction of the violation.

C) If it is determined that the violation or violations continue after the time fixed for abatement and correction has expired, the director shall issue a stop work order and citation by certified mail to the person who is in violation. Each such notice shall be in writing and shall describe the nature of the violation, including a reference to the provision within this ordinance which has been violated, and what penalty, if any, is proposed to be assessed. The person charged has thirty (30) days within which to contest the citation or proposed assessment of penalty and to file a request for a hearing with the director or his designee. At the conclusion of this hearing, the director or his designee will issue a final order, subject to appeal to the appropriate authority. If, within thirty (30) days from the receipt of the citation issued by the director, the person fails to contest the citation or proposed assessment of penalty, the citation or proposed assessment of penalty shall be deemed the final order of the director.

D) Any person who violates any provision of this ordinance may be liable for any cost or expenses (i.e., legal, professional consultation) incurred as a result thereof by the agency.

E) Penalties which may be assessed for those deemed to be in violation may include:

1) a civil penalty not to exceed one thousand dollars ($1,000.00) for each violation with each days continuance considered a separate violation,
2) a criminal penalty in the form of a fine of not more than one thousand dollars ($1,000.00) for each violation or imprisonment for not more than ninety (90) days, or both. Every day that such violations shall continue will be considered a separate offense, and
3) anyone who knowingly makes any false statements in any application, record, plat, or plan

Table C-1. Model ordinance for stream buffers (continued).

required by this ordinance shall upon conviction be punished by a fine of not more than one thousand dollars ($1,000.00) for each violation or imprisonment for not more than thirty (30) days, or both.

Specific penalties will vary between communities, and should reflect realistically enforceable penalties given the political realities of a jurisdiction.

F) In addition to any other sanctions listed in this ordinance, a person who fails to comply with provisions of this buffer ordinance shall be liable to the agency in a civil action for damages in an amount equal to twice the cost of restoring the buffer. Damages that are recovered in accordance with this action shall be used for the restoration of buffer systems or for the administration of programs for the protection and restoration of water quality, streams, wetlands, and floodplains.

Section IX. Waivers/Variances

A) This ordinance shall apply to all proposed development except for development which was initiated prior to the effective date of this ordinance:

1) is covered by a valid, unexpired plat in accordance with development regulations,
2) is covered by a current, executed public works agreement,
3) is covered by a valid, unexpired building permit,
4) has been accepted to apply for a building permit, and
5) has been granted a waiver in accordance with current development regulations.

B) The director of the agency may grant a variance for the following:

1) projects or activities where it can be demonstrated that strict compliance with the ordinance would result in practical difficulty or financial hardship,
2) projects or activities serving a public need where no feasible alternative is available,
3) repair and maintenance of public improvements where avoidance and minimization of adverse impacts to nontidal wetlands and associated aquatic ecosystems have been addressed, and
4) developments which have had buffers applied in conformance with previously issued requirements.

C) Waivers for development may also be granted in two additional forms, if deemed appropriate by the director:

Table C-1. Model ordinance for stream buffers (continued).

1) the buffer width made be relaxed and the buffer permitted to become narrower at some points as long as the average width of the buffer meets the minimum requirement. This averaging of the buffer may be used to allow for the presence of an existing structure or to recover a lost lot, as long as the streamside zone (Zone I) is not disturbed by the narrowing, and no new structures are built within the one hundred (100) year floodplain, and
2) (planning agency) may offer credit for additional developmental density elsewhere on the site in compensation for the loss of developable land due to the requirements of this ordinance. This compensation may increase the total number of dwelling units on the site up to the amount permitted under the base zoning.

D) The applicant shall submit a written request for a variance to the agency director. The application shall include specific reasons justifying the variance and any other information necessary to evaluate the proposed variance request. The agency may require an alternatives analysis that clearly demonstrates that no other feasible alternatives exist and that minimal impact will occur as a result of the project or development.

E) In granting a request for a variance, the agency director may require site design, landscape planting, fencing, the placement of signs, and the establishment of water quality best management practices to reduce adverse impacts on water quality, streams, wetlands, and floodplains.

Section X. Conflict With Other Regulations

Where the standards and management requirements of this buffer ordinance are in conflict with other laws, regulations, and policies regarding streams, steep slopes, erodible soils, wetlands, floodplains, timber harvesting, land disturbance activities or other environmental protective measures, the more restrictive shall apply.

References

Heraty, M. 1993. Riparian Buffer Programs: A Guide to Developing and Implementing a Riparian Buffer Program as an Urban Best Management Practice. Metropolitan Washington Council of Governments. USEPA Office of Wetlands, Oceans and Watersheds. Washington, D.C.

Schueler, T. 1995. Site Planning for Urban Stream Protection. Metropolitan Washington Council of Governments. USEPA Office of Wetlands, Oceans and Watersheds. Washington, D.C.

Table C-1. Model ordinance for stream buffers (continued).

Welsch, D. 1991. Riparian Forest Buffers. US Department of Agriculture, Forest Service. Forest Resources Management. FS Pub. No. NA-PR-07-91. Radnor, Pennsylvania.

Table C-2. Stream protection strategies under the watershed-based zoning framework.

Urban Stream Classification	Sensitive 0–10% Impervious Cover	Degrading 11–25% Impervious Cover	Non-supporting 26–100% Impervious Cover
Stream Quality Goal	Preserve biodiversity and channel stability at the predevelopment level.	Limit degradation to stream quality.	Minimize pollutant loads delivered to downstream waters.
Land Use Controls	Watershed-wide limits on impervious cover, and restrictions on specific site impervious cover.	Upper limit on watershed impervious cover.	No watershed imperviousness limits.
BMP Selection Criteria	Maintain pre-development hydrology. Minimize stream warming and sedimentation. Only off-stream ponds. Preference for filtering systems.	Maintain pre-development hydrology. Maximize pollutant removal. Use in ponds/wetlands with some restrictions.	Maximize pollutant removal and quantity control. Remove nitrogen, phosphorus, metals, and toxics. No restrictions on ponds and wetlands.
Streamside Management	Stream valley buffers, few uses allowed.	Stream buffers.	Greenways.

Table C-2. Stream protection strategies under the watershed-based zoning framework (continued).

Urban Stream Classification	Sensitive 0–10% Impervious Cover	Degrading 11–25% Impervious Cover	Non-supporting 26–100% Impervious Cover
Monitoring	Biological indicators (including single-species (e.g., trout).	Biological and physical indicators.	Water quality trends. BMP performance.
Enforcement	GIS tracking of impervious cover.	GIS, biomonitoring trends, BMP surveys.	Simulation model, water quality standards.
Development Rights	Transferred out.	No transfers.	Transferred in.
Other Tools	Land acquisition, extraordinary erosion and sediment control, special review.	Regional BMPs.	Pollution prevention, stormwater retrofits, illicit connections, restoration inventory.

Table C-3. Benefits of urban and community riparian forests and urban stream buffers.

1. **Reduces watershed imperviousness by 5%.** An average buffer width of 100 feet protects up to 5% of watershed area from future development.

2. **Distances areas of impervious cover from stream.** More room is made available for placement of BMPs and septic system performance is improved.

3. **Reduces small drainage problems and complaints.** When properties are located too close to a stream, residents are likely to experience and complain about backyard flooding, standing water, and bank erosion. A buffer greatly reduces complaints.

4. **Stream "right of way" allows for lateral movement.** Most stream channels shift or widen over time; a buffer protects both the stream and nearby properties.

5. **Effective flood control.** Other, expensive flood controls are not necessary if a buffer

Table C-3. Benefits of urban and community riparian forests and urban stream buffers (continued).

includes the 100-year floodplain.

6. **Protection from streambank erosion.** Tree roots consolidate the soils of floodplain and stream banks, reducing the potential for severe bank erosion.

7. **Increases property values.** Home buyers perceive buffers as attractive amenities to the community. Ninety percent of buffer administrators feel buffers have a neutral or positive impact on property value.

8. **Increased pollutant removal.** When designed properly, buffers can provide effective pollutant removal for development located within 150 feet of the buffer boundary.

9. **Foundation for present or future greenways.** Linear nature of the buffer provides for connected open space and trailways, allowing pedestrians and bicycles to move more efficiently through a community.

10. **Provides food and habitat for wildlife.** Leaf litter is the base food source for many stream ecosystems; forests also provide woody debris that creates cover and habitat structure for aquatic insects and fish.

11. **Mitigates stream warming.** Shading by the forest canopy prevents further stream warming in urban watersheds.

12. **Protection of associated wetlands.** A wide stream buffer can include riverine and palustrine wetlands that are frequently found near streams.

13. **Prevent disturbance to steep slopes.** Removing construction activity from steep slopes is the best way to prevent severe soil erosion rates.

14. **Preserves important terrestrial habitat.** Riparian corridors are important transition zones, rich in plant and animal species. A mile of stream buffer can provide 25 to 40 acres of habitat areas.

Table C-3. Benefits of urban and community riparian forests and urban stream buffers (continued).

15. **Corridors for conservation.** Unbroken stream buffers provide "highways" for plant and animal migrations.

16. **Essential habitat for amphibians.** Amphibians require both aquatic and terrestrial habitats and are dependent on riparian environments to complete their life cycle.

17. **Fewer barriers to fish migration.** Chances for migrating fish are improved when stream crossings are prevented or carefully planned.

18. **Discourages excessive storm drain enclosures/channel hardening.** Prevents increases in runoff from impervious cover and subsequent eroding or overflowing of headwater streams.

19. **Provides space for stormwater ponds.** When properly placed, structural BMPs within the buffer can be an ideal location to remove pollutants and control flows from urban areas and raise property values from 18 to 28%.

20. **Allowance for future restoration.** Even a modest buffer provides space and access for future stream restoration, bank stabilization, or reforestation.

Table C-4. Site factors that enhance or reduce pollutant removal performance in urban riparian forests or stream buffers.

Factors that enhance performance	Factors that reduce performance
Slopes less than 5%	Slopes greater than 5%
Contributing flow lengths <150 feet	Overland flow paths over 300 feet
Water table close to surface	Groundwater far below surface
Check dams/level spreaders	Contact times less than 5 minutes
Permeable, but not sandy soils	Compacted soils
Growing season	Non-growing season
Long length of buffer or swale	Buffers less than 10 feet

Table C-4. Site factors that enhance or reduce pollutant removal performance in urban riparian forests or stream buffers (continued).

Factors that enhance performance	Factors that reduce performance
Organic matter, humus, or mulch layer	Snowmelt conditions, ice cover
Small stormwater runoff events	Stormwater runoff events greater than 2 per year
Entry runoff velocity less than 1.5 feet per second	Entry runoff velocity more than 1.5 feet per second
Swales that are routinely mowed	Sediment buildup at top of swale
Poorly-drained soils, deep roots	Trees with shallow root systems
Dense grass cover, six inches tall	Tall grass, sparse vegetative cover

Table C-5. Shrubs and grasses adapted to urban and community riparian forests and stream buffers.

Common Name	Scientific Name	Height (ft.)	Drainage Adaptation	Plant Material*
Shrubs				
Acacia, Rose	*Robinia hispida*	2–10	Well to Excessively	Seedling
Alder, Smooth	*Alnus serrulata*	To 20	Well to Poorly	Seedling
Purple Beautyberry	*Callicarpa americana*	To 5	Well	Seedling
Buckeye, Red	*Aesculus pavia*	To 20	Well to Excessively	Seedling

Table C-5. Shrubs and grasses adapted to urban and community riparian forests and stream buffers (continued).

Common Name	Scientific Name	Height (ft.)	Drainage Adaptation	Plant Material*
Shrubs				
Buckhorn, Lanceleaf	*Rhamus caroliniana*	To 35	Well	Seedling
Burningbush	*Euonymus atropurpureus*	6–12	Well	Seedling
Buttonbush	*Cephalanthus occidentalis*	3–8	Poorly	Seedling, RC
Chinquapin, Eastern	*Castanea pumila*	10–15	Well to Excessively	Seedling
Corkwood	*Letneria floridana*	To 25	Poorly	Seedling
Dogwood, Gray	*Cornus racemosa*	To 10	Well to Poorly	Seedling, RC, URC
Dogwood, Roughleaf	*Cornus drummondi*	4–15	Well to Poorly	Seedling, RC, URC
Elderberry	*Sambucus canadensis*	3–13	Well to Poorly	Seedling, RC, URC
Groundsel-Tree	*Baccharis halimifolia*	To 9	Well to Poorly	Seedling, RC
Hawthorn	*Crataegus spp.*	To 15	Well to Excessively	Seedling

Table C-5. Shrubs and grasses adapted to urban and community riparian forests and stream buffers (continued).

Common Name	Scientific Name	Height (ft.)	Drainage Adaptation	Plant Material*
Shrubs				
Hazelnut	*Corylus americana*	To 10	Well to Excessively	Seedling
Holly, Deciduous	*Ilex decidua*	10–20	Well	Seedling
Holly, Yaupon	*Ilex vomitoria*	5–15	Well	Seedling
Hydrangea, Wild	*Hydrangea arborescens*	5–15	Well	Seedling
Indigobush	*Amorpha fruticosa*	To 13	Well to Excessively	Seedling, RC, URC
Pepperbush	*Clethra alnifolia*	To 10	Well to Poorly	Seedling
Plum, American	*Prunus americana*	15–30	Well to Excessively	Seedling
Plum, Chickasaw	*Prunus angustifolia*	To 20	Well to Excessively	Seedling
Privet, Swamp	*Forestiera acuminata*	To 12	Poorly	Seedling, RC
Spicebush, Common	*Lindera benzoi*	To 12	Well to Poorly	Seedling
Spicebush, Hairy	*Lindera melissaefolium*	To 6	Poorly	Seedling

Table C-5. Shrubs and grasses adapted to urban and community riparian forests and stream buffers (continued).

Common Name	Scientific Name	Height (ft.)	Drainage Adaptation	Plant Material*
Shrubs				
Spirea, Steeplebush	*Spirea tomentos*	To 5	Well to Poorly	Seedling, RC
Sumac, Smooth	*Rhus glabra*	4–15	Well to Excessively	Seedling, Rhizome
Sumac, Winged	*Rhus copallina*	4–10	Well to Excessively	Seedling
Tea, New Jersey	*Ceanothus americanus*	To 4	Well to Excessively	Seedling
Viburnum, Blackhaw	*Viburnum prunifoium*	6–15	Well	Seedling
Viburnum, Rusty	*Virburnum rufidulum*	6–18	Well	Seedling
Viburnum, Wild Raisin	*Viburnum nudum*	To 20	Well to Poorly	Seedling
Waxmyrtle	*Myrcia cerifera*	10–30	Well to Excessively	Seedling
Willow, Tall Prairie	*Salix humilis*	To 13	Well to Poorly	RC, URC
Witch-hazel	*Hamamelis virginiana*	10–25	Well	Seedling

Table C-5. Shrubs and grasses adapted to urban and community riparian forests and stream buffers (continued).

Common Name	Scientific Name	Height (ft.)	Drainage Adaptation	Plant Material*
Grasses				
Bluestem, Big	*Andropogon gerardii*	4–6	Well to Excessively	Seed
Bluestem, Little	*Schizacharium scoparium*	2–4	Well to Excessively	Seed
Gamegrass, Eastern	*Tripsacum dactyloides*	5–9	Excessively to Poorly	Seed
Indiangrass	*Sorghastrum nutans*	3–7	Well to Exces-sively	Seed
Maidencane	*Panicum hemitomon*	2–5	Well to Poorly	Rhizomes

*RC=Root cutting, URC=Un-rooted cutting.

Table C-6. Bush, legume, and grass seed planting guide for urban and community riparian forests and stream buffers.

		Planting Date			Planting Rate
Common Name	Type*	Zone 1	Zone 2	Zone 3	Lbs. per acre
Bicolor Lespedeza (seed)	Bush (P)	April to July	April to July	May to July	16
Bicolor Lespedeza (plants)	Bush (P)	January	January	January	1,000
Korean Lespedeza	Legume (A)	March to June	April to June	April to June	30
Browntop Millet	Grass (A)	Early spring to late summer			10
Dove Proso Millet	Grass (A)	Early spring to late summer			10
Japanese Millet	Grass (A)	Early spring to late summer			10
Georgia One Birdsfoot Trefoil*	Legume (P)	X	September	August 15	8
Bigbee Berseem Clover	Legume (A)	October	September	August	10
Crimson Clover	Legume (A)	October	September	August	10
Osceola Ladino Clover	Legume (P)	October	September	August	5

Table C-6. Bush, legume, and grass seed planting guide for urban and community riparian forests and stream buffers (continued).

		Planting Date			Planting Rate
Common Name	Type*	Zone 1	Zone 2	Zone 3	Lbs. per acre
Regal Ladino Clover	Legume (P)	October	September	August	5
White Clover	Legume (A)	October	September	August	5
Yuchi Arrowleaf Clover	Legume (A)	October	September	August	5
Wrenns Abruzzi Rye	Grain (A)	October	September	August	100
Iron Clay Peas	Legume (A)	March to Sept.	April to Sept.	April to Sept.	30
Lathco Flat Pea	Legume (P)	March	April	April	13
Sesbania	Legume (A)	March	April	May	10
Switchgrass	Grass (P)	Jan. to July	Feb. to May	March to May	4
Big Bluestem	Grass (P)	Jan. to July	Feb. to May	March to May	4
Little Bluestem	Grass (P)	Jan. to July	Feb. to May	March to May	2

Table C-6. Bush, legume, and grass seed planting guide for urban and community riparian forests and stream buffers (continued).

		Planting Date			Planting Rate
Common Name	Type*	Zone 1	Zone 2	Zone 3	Lbs. per acre
Eastern Gamagrass	Grass (P)	Jan. to July	Feb. to May	March to May	8
Yellow Indiangrass	Grass (P)	Jan. to July	Feb. to May	March to May	2–4
Maidencane	Grass (P)	March to July	Feb. to Jun	March to June	10–15,000
Virginia Wildrye	Grass (P)	March to July	Feb. to May	March to May	5
Kleingrass	Grass (P)	March to July	Feb. to May	March to May	10
Rye	Grass (A)	Aug. 25 to Oct. 1	Sept. 1 to Oct. 15	Sept. 15 to Nov. 1	10–20
Wheat	Grass (A)	Aug. 25 to Oct. 1	Sept. 1 to Oct. 15	Sept. 15 to Nov. 1	1 bushel
Northpa, Southpa Bitter Panicum	Grass (P)	Mar to Jun**		April to June**	15–20,000

X – Not adapted or recommended
* (P) = Perennial; (A) = Annual
** Vegetative propagation only

Table C-7. Tree, shrub, and vine planting guide for urban riparian forests and urban stream buffers.

		Planting Date			Spacing
Common Name	Type	Zone 1	Zone 2	Zone 3	Feet
Chinquepin Oak	Shrub	Jan. to Feb.	Jan. to March	Dec. to April	20 to 50
Sawtooth Oak	Tree	Jan. to Feb.	Jan. to March	Dec. to April	20 to 50
Wild Pear	Shrub	Jan. to Feb.	Jan. to March	Dec. to April	20 to 50
Wild Persimmon	Small tree	Jan. to Feb.	Jan. to March	Dec. to April	20 to 50
Wild Plum	Shrub	Jan. to Feb.	Jan. to March	Dec. to April	10 to 20
Hawthorn	Tree	Jan. to Feb.	Jan. to March	Dec. to April	20 to 50
Black Cherry	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Huckleberry	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Red Mulberry	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Flowering Dogwood	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50

Table C-7. Tree, shrub, and vine planting guide for urban riparian forests and urban stream buffers (continued).

		Planting Date			Spacing
Common Name	Type	Zone 1	Zone 2	Zone 3	Feet
Sweetgum	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
American Beech	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Sugarberry	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Big O Crabapple	Small tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Gobbler Sawtooth Oak	Tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Golden Chinquepin	Small tree	Jan. to Feb.	Jan. to March	Dec. to April	30 to 50
Ellagood Autumn Olive	Shrub	Jan. to Feb.	Jan. to March	Dec. to April	20 to 30
Chestnut var Edward	Tree	Jan. to Feb.	Jan. to March	Dec. to April	25 to 30
Mayhaws	Shrub	Jan. to Feb.	Jan. to March	Dec. to April	10 to 20
Wax Myrtle	Shrub	Jan. to Feb.	Jan. to March	Dec. to April	10 to 20

Table C-7. Tree, shrub, and vine planting guide for urban riparian forests and urban stream buffers (continued).

		Planting Date			Spacing
Common Name	Type	Zone 1	Zone 2	Zone 3	Feet
Black Locust	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Honey Locust	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Bitternut Hickory	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Mockernut Hickory	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Shagbark Hickory	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Pignut Hickory	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Blackgum	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Hackberry	Tree	Jan. to Feb.	Jan. to March	Dec. to April	50
Wild grapes	Vine	Jan. to Feb.	Jan. to March	Dec. to April	2 x 2
Honeysuckle	Vine	Jan. to Feb.	Jan. to March	Dec. to April	2 x 2

Table C-8. The three-zone urban and community riparian forest or stream buffer system.

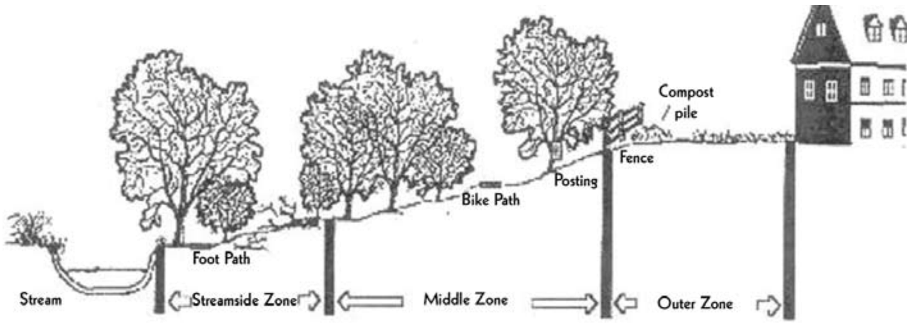

Figure 2: Three-zone buffer system (Adapted from Welsch, 1991).

Characteristics	Streamside Zone	Middle Zone	Outer Zone
Function	Protect the physical integrity of the stream ecosystem.	Provide distance between upland development and streamside zone.	Prevent encroachment and filter backyard runoff.
Width	Minimum 25 feet, plus wetlands and critical habitats.	Fifty to 100 feet, depending on stream order, slope, and 100–year floodplain.	Twenty-five feet minimum, setback to structures.
Vegetative Target	Undisturbed mature forest, reforest if grass.	Managed forest, some cleaning allowable.	Forest encouraged, but usually turfgrass.
Allowable Uses	Very Restricted (e.g., flood control, utility right of ways, footpaths)	Restricted (e.g., some recreational uses, some stormwater BMPs, bike paths, tree removal by permit)	Unrestricted (e.g., residential uses including lawn, garden, compost, yard wastes, most stormwater BMPs)

Appendix D - Vegetation Recommendations

Table D-1. Recommended species and seeding rates for temporary cover in urban and community areas of Mississippi.

Recommended Species for Temporary Cover		
Species	**Preferred Planting Dates**	**Seeding Rate**
Browntop Millet	May–July 15	25 lbs. seed/acre
Sorghum/Sudangrass	April–July	35 lbs. seed/acre
Ryegrass (Gulf or Marshall)	September–October	30 lbs. seed/acre
Oats (Florida 501 Bob)	September–October	4 bushels/acre
Wheat	September–October	2 bushels/acre
Rye (Vitagraze)	September–October	2 bushels/acre

Table D-2. Recommended species and seeding rates for permanent cover in urban and community areas of Mississippi.

Recommended Species for Permanent Cover		
Species	**Preferred Planting Dates**	**Seeding Rate**
Lespedeza (Sericea)	March–April	30 lbs. seed/acre
Fescue (Ky-31)	September–November	20 lbs. seed/acre
Bahiagrass	February–June or September–November	30 lbs. seed/acre
Bermudagrass (hulled)	March–June	8 lbs. seed/acre

Table D-3. Recommended species and seeding rates for wildlife plantings in urban and community areas of Mississippi.

Wildlife Planting Recommendations*		
Species	**Preferred Planting Dates**	**Seeding Rate**
Browntop Millet	May–July 15	20 lbs. seed/acre
Oats	September–October	4 bushels/acre
Wheat	September–October	20 lbs. seed/acre
Winter Peas	September–October	30 lbs. seed/acre
Red Clover (Redland, Atlas)	September–October 15	8 lbs. seed/acre
White Clover (Regal, Osceola)	September–October	3 lbs. seed/acre

*Some landowners may wish to establish vegetation which will provide both ground cover and benefit wildlife species. This table lists those plants which may serve both purposes.

Table D-4. Seeding chart for common grasses for urban and community areas of Mississippi.

Species	Seeding Rate/ Acre	Planting Time	Desired pH Range	Fertilization Rate	Method of Establishment	Zone[1]
Common Bermuda	15 lbs. alone 10 lbs. mixture	3/1–7/15 9/1–11/30	6.0–7.0	600 lbs., 13-13-13	Seed or sod	All
Bahia	40 lbs. alone 30 lbs. mixture	2/1–7/15 9/1–11/30	6.0–7.0	600 lbs., 13-13-13	Seed	South, Central
Fescue	40 lbs. alone 30 lbs. mixture	9/1–11/30	6.0–7.0	600 lbs., 13-13-13	Seed	North, Central
Saint Augustine	N/A	3/1–7/15	6.0–7.0	600 lbs., 13-13-13	Sod or plugs only	South, Central

Table D-4. Seeding chart for common grasses for urban and community areas of Mississippi (continued).

Species	Seeding Rate/ Acre	Planting Time	Desired pH Range	Fertilization Rate	Method of Establishment	Zone[1]
Centi-pede	4 lbs. alone 2½ lbs. mix-ture	3/1–7/15	6.0–7.0	600 lbs., 13-13-13	Seed or sod	All
Carpet Grass	15 lbs. alone 10 lbs. mixture	3/1–7/15	6.0–7.0	600 lbs., 13-13-13	Seed or sod	All
Oysia Grass	N/A	3/1–7/15	6.0–7.0	600 lbs., 13-13-13	Sod or plugs only	All
Creep-ing Red Fescue	30 lbs. alone 22½ lbs. mixture	9/1–11/30	6.0–7.0	600 lbs., 13-13-13	Seed	All
Weeping Loveg-rass	10 lbs. alone 5 lbs. mixture	3/1–7/15	6.0–7.0	600 lbs., 13-13-13	Seed	All
Wheat*	90 lbs. alone	9/1–11/30	6.0–7.0	600 lbs., 13-13-13	Seed	All
Rye-grass*	30 lbs.	9/1–11/30	6.0–7.0	600 lbs., 13-13-13	Seed	All
White Clover*	5 lbs.	9/1–11/30	6.0–7.0	400 lbs., 13-13-13	Seed	All
Crimson Clover*	25 lbs. alone 15 lbs. mixture	9/1–11/30	6.0–7.0	400 lbs., 13-13-13	Seed	All
Hairy Vetch*	30 lbs.	9/1–11/30	6.0–7.0	400 lbs., 13-13-13	Seed	All
Brown-top Millet*	40 lbs. alone 15 lbs. mixture	4/1–8/30	6.0–7.0	600 lbs., 13-13-13	Seed	All

*Annuals. For permanent seeding, annuals can only be used in a mixture with perennials.

[1]North–north of Highway 82; Central–south of Highway 82 and north of Highway 84; South–south of Highway 84.

Table D-5. Recommended trees for medians, parking lots, and shopping centers in urban and community areas.*

Common Name	Botanical Name	Upright Form	Road Salt Tolerance	Tolerates Harsh Conditions[1]
Armstrong Red Maple	*Acer rubrum Armstrongí*	√	√	√
Goldspire Sugar Maple	*Acer saccharum Goldspireí*	√		√
Cumulus Serviceberry	*Amelanchiar x grandiflora Cumulusí*	√	√	
Fastiginate Hornbeam	*Carpinus betulus Fastigiataí*	√		√
Sugar Hackberry	*Celtis lacvigata*		√	√
Dawyck Purple Beech	*Fagus sylvatica Dawyck Purpleî*	√		
Fastigiata Beech	*Fagus sylvatica Fastigiataí*	√		
Green Ash	*Fraxinus pennsylvanica*		√	√
Fastigiata Ginkgo	*Ginkgo biloba Fastigiataí*	√		√
Lakeview Ginkgo	*Ginkgo biloba Lakeviewí*	√		√
Princeton Sentry Ginkgo	*Ginkgo biloba Princeton Sentryí*	√		√
Thornless Honeylocust	*Gleditsia triacanthos var. inermis*		√	√
Hawthorns	*Hawthorn spp.*		√	√
Eastern Redcedar	*Juniperus virginiana*	√	√	
Golden Raintree	*Koelreuteria paniculata*		√	√
Sweetgum	*Liquidambar styraciflua*			√
Little Gem Magnolia	*Magnolia grandiflora Little Gemí*	√		√
Sycamore	*Platanus occidentalis*			√
Carolina Laurel Cherry	*Prunus caroliniana*			√
Purple-Leaf Plum	*Prunus cerasifera Atropurpurcaí*			√
Bradford or Flowering Pear	*Pyrus calleryana Capitolí*	√		
Skyrocket English Oak	*Quercus robur Fastigiataí*	√	√	

Table D-5. Recommended trees for medians, parking lots, and shopping centers in urban and community areas (continued).*

Common Name	Botanical Name	Upright Form	Road Salt Tolerance	Tolerates Harsh Conditions[1]
Baldcypress	*Taxodium distichum*		√	√
Littleleaf Linden	*Tilia cordata*	√	√	√
Lacebark Elm	*Ulmus parvifolia*			√

*Listed tree species are suitable for median plantings in Tennessee. Ask for and obtain the correct cultivar or variety in your community. Many of these trees have been cultivated to provide an upright crown form that is preferred for medians and other landscape purposes. [1]Harsh conditions include: restricted root space, narrow growing space, and city environments.

Table D-6. List of recommended uses for tree species suitable for urban and community forestry environments in the Southeast.

		Mature Canopy Area		Recommended Uses								
Common Name	Latin Name	Square feet of Canopy[1]	Canopy Size Category[2]	Level of Use[3]	Large Landscape Areas[4]	Road Frontages - Street[4]	Road Frontages - Yard[4]	Parking Lots[4]	Plazas/Downtown Settings[4]	Buffers[4]	Riparian Zones/Drainage Areas[4]	Utility Corridors[4]
Ash, Green	*Fraxinus pennsylvanica*	1,600	L	P	E	G	E		G		G	
Ash, White	*Fraxinus americana*	1,600	L	P	E	G	E		G		G	
Baldcypress	*Taxodium distichum*	900	M	P	G		E			E	E	

see page 155 for footnotes describing letters used in this table.

Table D-6. List of recommended uses for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Mature Canopy Area		Recommended Uses								
Common Name	Latin Name	Square feet of Canopy[1]	Canopy Size Category[2]	Level of Use[3]	Large Landscape Areas[4]	Road Frontages - Street[4]	Road Frontages - Yard[4]	Parking Lots[4]	Plazas/Downtown Settings[4]	Buffers[4]	Riparian Zones/Drainage Areas[4]	Utility Corridors[4]
Beech, American	*Fagus grandifolia*	1,600	L	P	E					X	G	
Birch, River	*Betula nigra*	900	M	P	E	G	E	G	E	E	E	X
Birch, River 'Heritage'	*Betula nigra 'Heritage'*	900	M	P	E	G	E	G	E	E	E	X
Blackgum (Tupelo)	*Nyssa sylvatica*	900	M	P	E	G	E				G	
Boxelder	*Acer negundo*	900	M	C	G						G	X
Catalpa, Southern	*Catalpa bignonioides*	900	M	C	G	X		X			G	
Cherry, Black	*Prunus serotina*	900	M	C	G		G				G	
Cottonwood, Eastern	*Populus deltoides*	1,600	L	C	G					X	G	
Crapemyrtle, Common	*Lagerstroemia indica*	150	VS	P		E	E	E	E	E	X	E
Dogwood, Flowering	*Cornus florida*	400	S	P	E	E	E	X	X	E		E
Dogwood Flower. Pink	*Cornus florida var. rubra*	400	S	P	E	E	E	E	X	X	E	G
Elm, American	*Ulmus americana*	1,600	L	C	G		G				G	

see page 155 for footnotes describing letters used in this table.

Table D-6. List of recommended uses for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Mature Canopy Area		Recommended Uses								
Common Name	Latin Name	Square feet of Canopy[1]	Canopy Size Category[2]	Level of Use[3]	Large Landscape Areas[4]	Road Frontages - Street[4]	Road Frontages - Yard[4]	Parking Lots[4]	Plazas/Downtown Settings[4]	Buffers[4]	Riparian Zones/Drainage Areas[4]	Utility Corridors[4]
Elm, Slippery	*Ulmus rubra*	1,600	L	C	G	G	G				G	
Elm, Winged	*Ulmus alata*	1,600	L	P	E	E	E	E		X	X	
Hickory, Bitternut	*Carya cordiformis*	1,600	L	C	G	X	G	X	X			
Hickory, Mockernut	*Carya tomentosa*	1,600	L	C	G	X	G	X	X			
Hickory, Pignut	*Carya glabra*	1,600	L	C	G	X	G	X	X			
Hickory, Shagbark	*Carya ovata*	1,600	L	C	G	X	G	X	X			
Hickory, So. Shagbark	*Carya ovata var. australis*	1,600	L	C	G	X	G	X	X			
Holly, American	*Ilex opaca*	150	VS	P	G		E	G		E		X
Holly, Deciduous	*Ilex decidua*	150	VS	C	G		G				G	G
Honeylocust	*Gleditsia triacanthos*	900	M	C	G		G	X	X			
Hophornbeam, American	*Ostrya virginiana*	900	M	P	G		G	G			G	
Hornbeam, American	*Carpinus caroliniana*	900	M	P	E	E	E	G	E	E	E	
Magnolia, Cucumber	*Magnolia acuminata*	1,600	L	C	G		G	X		G		

see page 155 for footnotes describing letters used in this table.

Table D-6. List of recommended uses for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Mature Canopy Area		Recommended Uses								
Common Name	Latin Name	Square feet of Canopy[1]	Canopy Size Category[2]	Level of Use[3]	Large Landscape Areas[4]	Road Frontages - Street[4]	Road Frontages - Yard[4]	Parking Lots[4]	Plazas/Downtown Settings[4]	Buffers[4]	Riparian Zones/Drainage Areas[4]	Utility Corridors[4]
Magnolia, Southern	*Magnolia grandiflora*	1,600	L	P	E		E	X		E		X
Magnolia, So. 'Little Gem'	*Magnolia grandiflora 'Little Gem'*	150	VS	P			G	X		G		E
Magnolia, Sweetbay	*Magnolia virginiana*	900	M	P	E		G			E	E	
Maple, Red	*Acer rubrum*	900	M	P	E	G	E	G	E	E	G	
Maple, Silver	*Acer sacchrainum*	1,600	L	P	E	E	E				G	X
Maple, Florida Sugar	*Acer barbatum*	900	M	P	E	E	E					X
Maple, Sugar	*Acer sacchraum*	1,600	L	P	E	E	E					X
Maple, Sugar 'Legacy'	*Acer saccharum 'Legacy'*	1,600	L	C	G		G				G	
Mulberry, Red	*Morus rubra*	900	M	P	G		G				G	
Oak, Black	*Quercus velutina*	1,600	L	P	G	G	G					
Oak, Cherrybark	*Quercus falcata*	1,600	L	P	E	G	E					
Oak, Diamond Leaf	*Quercus laurifolia*	1,600	L	P	G	G	G					

see page 155 for footnotes describing letters used in this table.

Table D-6. List of recommended uses for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Mature Canopy Area		Recommended Uses								
Common Name	Latin Name	Square feet of Canopy[1]	Canopy Size Category[2]	Level of Use[3]	Large Landscape Areas[4]	Road Frontages - Street[4]	Road Frontages - Yard[4]	Parking Lots[4]	Plazas/Downtown Settings[4]	Buffers[4]	Riparian Zones/Drainage Areas[4]	Utility Corridors[4]
Oak, Northern Red	*Quercus rubra*	1,600	L	P	E	E	E				G	
Oak, Nuttall	*Quercus nuttalli*	1,600	L	C	G	G	E					
Oak, Overcup	*Quercus lyrata*	1,600	L	P	E	E	E	G	G			
Oak, Post	*Quercus stellata*	1,600	L	P	E	E	E	E	E			
Oak, Scarlet	*Quercus coccinea*	1,600	L	P	E	G	E				G	
Oak, Shumard	*Quercus shumardii*	1,600	L	P	G	X	G	X	X		G	
Oak, Southern Red	*Quercus falcata*	1,600	L	P	E	G	E	G	E	E	G	
Oak, Swamp Chestnut	*Quercus michauxii*	1,600	L	P	E	E	E				G	X
Oak, Water	*Quercus nigra*	1,600	L	P	E	G	E				E	X
Oak, White	*Quercus alba*	1,600	L	P	E	G	E					
Oak, Willow	*Quercus phellos*	1,600	L	P	E	E	E	E	E	X	E	X
Pecan	*Carya illinoensis*	1,600	L	P	G	X	G	X	X	X		
Persimmon, Common	*Diospyros virginiana*	900	M	P	X	X	G	X	X		G	
Pine, Loblolly	*Pinus taeda*	1,600	L	P	E	G	G	E		E	G	X
Pine, Longleaf	*Pinus palustris*	1,600	L	C			G	G		E	X	

see page 155 for footnotes describing letters used in this table.

Table D-6. List of recommended uses for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Mature Canopy Area		Recommended Uses								
Common Name	Latin Name	Square feet of Canopy[1]	Canopy Size Category[2]	Level of Use[3]	Large Landscape Areas[4]	Road Frontages - Street[4]	Road Frontages - Yard[4]	Parking Lots[4]	Plazas/Downtown Settings[4]	Buffers[4]	Riparian Zones/Drainage Areas[4]	Utility Corridors[4]
Pine, Shortleaf	*Pinus echinata*	1,600	L	P	E	G	G	G		G	G	X
Pine, Slash	*Pinus elliotii*	1,600	L	C			G	G		G	X	
Plum, Chickasaw	*Prunus angustifolia*	1,600	L	P	G	E	E	E				
Poplar, Yellow	*Liriodendron tulipifera*	900	L	C			G					
Redbud, Eastern	*Cercis canadensis*	1,600	L	P	E		G				E	X
Redbud, E. White	*Cercis canadensis (alba)*	400	S	P	E	E	E		E	E	G	E
Redcedar, Eastern	*Juniperus virginiana*	400	S	P		E	E	G	E			E
Sassafras	*Sassafras albidum*	900	M	L		X	G	X	X		X	
Sourwood	*Oxydendrum arboreum*	150	VS	L			G					G
Sweetgum	*Liquidambar styraciflua*	1,600	L	C	G		G			X	G	
Sycamore	*Platunus occidentalis*	1,600	L	P	G		G		G			
Willow, Black	*Salix nigra*	150	VS	P			G	G		G	X	G

see page 155 for footnotes describing letters used in this table.

Table D-6. List of recommended uses for tree species suitable for urban and community forestry environments in the Southeast (continued).

[1]The total area projection of the crown onto the ground in square feet as typically achieved in urban situations with less than optimal growing conditions.

[2]VS—Very Small - 150 square feet with a 15 foot crown diameter (minimum open soil surface area is 25 sq. ft.).

S—Small – 400 square feet with a 25 foot crown diameter (minimum open soil surface area is 100 sq. ft.).

M—Medium – 900 square feet with a 35 foot crown diameter (minimum open soil surface area is 225 sq. ft.).

L—Large – 1,600 square feet with a 45 foot crown diameter (minimum open soil surface area is 400 sq. ft.).

[3]P = Plant new trees and conserve existing trees;

C = Conserve existing trees;

L = For limited planting or conservation only;

N = Do not plant;

[4]X = tree to avoid, not suitable;

Blank = may or may not be suitable;

G = Good choice;

E = Excellent choice.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast.

Common Name	Latin Name	Physical Characteristics										
		Height Class in Urban Conditions[1]	Crown Class in Urban Conditions[2]	Mature Crown Form[3]	Range of Mature Tree Height[4]	Range of Mature Crown Width[5]	Leaf Type[6]	Fall Leaf Color[7]	Flower Color[8]	Flowering Time	Wildlife Value[9]	Excessive Litter[10]
Ash, Green	*Fraxinus pennsylvanica*	L	L	R	60-100	40-50	DB	V	I		X	
Ash, White	*Fraxinus americana*	L	L	R	50-80	30-60	DB	M	I		X	
Baldcypress	*Taxodium distichum*	L	M	P	50-100	20-50	DC	B	I		X	
Beech, American	*Fagus grandifolia*	L	L	O	80-100	50-70	DB	Y	I		X	
Birch, River	*Betula nigra*	M	M	P	50-90	40-60	DB	Y	I			
Birch, River 'Heritage'	*Betula nigra 'Heritage'*	M	M	P	50-90	40-60	DB	Y	I			
Blackgum (Tupelo)	*Nyssa sylvatica*	M	M	O	50-100	20-35	DB	R	I		X	
Boxelder	*Acer negundo*	M	M	R	30-40	30-40	DB	Y	W	Sp	X	X
Catalpa, Southern	*Catalpa bignonioides*	L	M	O	50-90	15-50	DB	Y	W	Sp	X	
Cherry, Black	*Prunus serotina*	L	L	P	50-100	20-75	DB	Y	I		X	X
Cottonwood, Eastern	*Populus deltoides*	L	L	P	50-100	20-75	DB	Y	I		X	X

see page 162 for footnotes describing letters used in this table.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast (continued).

Common Name	Latin Name	Physical Characteristics										
		Height Class in Urban Conditions[1]	Crown Class in Urban Conditions[2]	Mature Crown Form[3]	Range of Mature Tree Height[4]	Range of Mature Crown Width[5]	Leaf Type[6]	Fall Leaf Color[7]	Flower Color[8]	Flowering Time	Wildlife Value[9]	Excessive Litter[10]
Crapemyrtle, Comm.	*Lagerstroemia indica*	S	VS	MS	15-30	10-25	DB	R	M	Su		
Dogwood, Flowering	*Cornus florida*	S	S	S	15-30	15-30	DB	R	W	Sp	X	
Dogwood, Flow. Pink	*Cornus florida var. rubra*	S	S	S	15-30	15-30	DB	R	P	Sp	X	
Elm, American	*Ulmus americana*	L	L	U	50-100	30-70	DB	Y	I		X	
Elm, Slippery	*Ulmus rubra*	L	L	U	70-80	30-50	DB	Y	I		X	
Elm, Winged	*Ulmus alata*	L	L	U	70-80	30-50	DB	Y	I			
Hickory, Bitternut	*Carya cordiformis*	L	L	O	50-100	50-75	DB	Y	I		X	
Hickory, Mockernut	*Carya tomentosa*	L	L	O	50-100	50-75	DB	Y	I		X	X
Hickory, Pignut	*Carya glabra*	L	L	O	50-100	50-75	DB	Y	I		X	
Hickory, Shagbark	*Carya ovata*	L	L	O	70-100	50-75	DB	Y	I		X	
Hickory, S. Shagbark	*Varya ovata var. australis*	L	L	O	60-80	40-60	DB	Y	I		X	

see page 162 for footnotes describing letters used in this table.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast (continued).

Common Name	Latin Name	Physical Characteristics										
		Height Class in Urban Conditions[1]	Crown Class in Urban Conditions[2]	Mature Crown Form[3]	Range of Mature Tree Height[4]	Range of Mature Crown Width[5]	Leaf Type[6]	Fall Leaf Color[7]	Flower Color[8]	Flowering Time	Wildlife Value[9]	Excessive Litter[10]
Holly, American	*Ilex opaca*	M	VS	P	20-70	15-25	EB	E	I		X	
Holly, Deciduous	*Ilex decidua*	S	VS	R	10-20	10-20	DB	I	I		X	
Honeylocust	*Gleditsia triacanthos*	L	M	I	60-80	30-50	DB	Y	I			
Hophornbeam, Am.	*Ostrya virginiana*	M	M	O	15-40	10-30	DB	Y	W	Su	X	
Hornbeam, Am.	*Carpinus caroliniana*	M	M	O	20-35	15-30	DB	Y	I		X	
Magnolia, Cucumber	*Magnolia acuminata*	L	L	U	60-80	30-50	DB	Y	W	Sp	X	
Magnolia, Southern	*Magnolia grandiflora*	L	L	P	80-100	30-50	EB	E	W	Sp	X	X
Magnolia, Southern 'Little Gem'	*Magnolia grandiflora 'Little Gem'*	M	VS	P	40-60	20-30	EB	E	W	Sp	X	X
Magnolia, Sweetbay	*Magnolia virginiana*	L	L	U	70-80	30-50	DB	Y	I			
Maple, Red	*Acer rubrum*	M	M	R	40-90	20-35	DB	R	R	Wi	X	
Maple, Silver	*Acer saccharinum*	L	L	R	50-80	40-60	DB	Y	I			
Maple, Florida Sugar	*Acer barbatum*	M	M	R	40-70	25-60	DB	O	I			

see page 162 for footnotes describing letters used in this table.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Physical Characteristics										
Common Name	Latin Name	Height Class in Urban Conditions[1]	Crown Class in Urban Conditions[2]	Mature Crown Form[3]	Range of Mature Tree Height[4]	Range of Mature Crown Width[5]	Leaf Type[6]	Fall Leaf Color[7]	Flower Color[8]	Flowering Time	Wildlife Value[9]	Excessive Litter[10]
Maple, Sugar	*Acer saccharum*	L	L	O	60-80	30-50	DB	O	I		X	
Maple, Su. 'Green Mtn'	*Acer sach. 'Green Mtn'*	L	L	0	60-80	30-50	DB	O	I		X	
Maple, Sugar 'Legacy'	*Acer saccharum 'Legacy'*	L	L	O	60-80	30-50	DB	O	I		X	
Mulberry, Red	*Morus rubra*	L	M	R	40-70	20-50	DB	Y	I		X	X
Oak, Black	*Quercus velutina*	L	L	R	70-90	50-60	DB	R	I		X	
Oak, Cherrybark	*Quercus falcata*	L	L	R	60-100	30-50	DB	R	I		X	
Oak, Diamond Leaf	*Quercus laurifolia*	L	L	R	60-80	50-60	DB	Y	I		X	
Oak, Northern Red	*Quercus rubra*	L	L	R	60-100	30-60	DB	R	I		X	
Oak, Nuttall	*Quercus nuttalli*	L	L	R	60-80	35-50	DB	R	I		X	
Oak, Overcup	*Quercus lyrata*	L	L	R	30-45	30-45	DB	B	I		X	
Oak, Post	*Quercus stellata*	L	L	R	40-50	35-40	DB	B	I		X	

see page 162 for footnotes describing letters used in this table.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Physical Characteristics										
Common Name	Latin Name	Height Class in Urban Conditions[1]	Crown Class in Urban Conditions[2]	Mature Crown Form[3]	Range of Mature Tree Height[4]	Range of Mature Crown Width[5]	Leaf Type[6]	Fall Leaf Color[7]	Flower Color[8]	Flowering Time	Wildlife Value[9]	Excessive Litter[10]
Oak, Scarlet	*Quercus coccinea*	L	L	R	50-80	30-50	DB	R	I		X	
Oak, Shumard	*Quercus shumardii*	L	L	R	60-100	30-70	DB	R	I		X	
Oak, Southern Red	*Quercus falcata*	L	L	R	60-100	30-70	DB	O	I		X	
Oak, Swamp Chestnut	*Quercus michauxii*	L	L	O	70-90	30-60	DB	Y	I		X	
Oak, Water	*Quercus nigra*	L	L	R	50-100	30-70	DB	Y	I		X	
Oak, White	*Quercus alba*	L	L	R	60-100	30-80	DB	R	I		X	
Oak, Willow	*Quercus phellos*	L	L	R	40-100	30-60	DB	Y	I		X	
Pecan	*Carya illinoensis*	L	L	U	60-100	30-75	DB	Y	I		X	X
Persimmon, Common	*Diospyros virginiana*	L	M	O	70-80	40-60	DB	R	I		X	X
Pine, Loblolly	*Pinus taeda*	L	L	P	80-100	20-40	EC	E	I		X	
Pine, Longleaf	*Pinus palustris*	L	L	P	60-100	20-40	EC	E	I		X	

see page 162 for footnotes describing letters used in this table.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast (continued).

Common Name	Latin Name	Physical Characteristics										
		Height Class in Urban Conditions[1]	Crown Class in Urban Conditions[2]	Mature Crown Form[3]	Range of Mature Tree Height[4]	Range of Mature Crown Width[5]	Leaf Type[6]	Fall Leaf Color[7]	Flower Color[8]	Flowering Time	Wildlife Value[9]	Excessive Litter[10]
Pine, Shortleaf	*Pinus echinata*	L	L	P	60-100	20-40	EC	E	I		X	
Pine, Slash	*Pinus elliotii*	L	L	P	60-100	20-50	EC	E	I		X	
Plum, Chickasaw	*Prunus angustifolia*	L	L	I	60-100	20-80	DB	Y	I			
Poplar, Yellow	*Liriodendron tulipifera*	L	M	O	40-100	20-60	DB	Y	I			
Redbud, Eastern	*Cercis canadensis*	L	L	O	80-150	30-60	DB	Y	Y	Sp	X	
Redbud, E. White	*Cercis canadensis (alba)*	S	S	S	25-50	15-25	DB	Y	P	Sp	X	
Redcedar, Eastern	*Juniperus virginiana*	S	S	R	20-25	15-20	DB	Y	W	Sp	X	
Sassafras	*Sassafras albidum*	M	M	I	30-50	20-50	DB	Y	P	Sp		X
Sourwood	*Oxydendrum arboreum*	S	VS	O	10-15	10-15	DB	V	P	Sp		
Sweetgum	*Liquidamar styraciflua*	L	L	S	60-80	25-60	DB	Y	I		X	
Sycamore	*Platanus occidentalis*	L	L	O	50-70	35-45	DB	V	I			

see page 162 for footnotes describing letters used in this table.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Physical Characteristics										
Common Name	Latin Name	Height Class in Urban Conditions[1]	Crown Class in Urban Conditions[2]	Mature Crown Form[3]	Range of Mature Tree Height[4]	Range of Mature Crown Width[5]	Leaf Type[6]	Fall Leaf Color[7]	Flower Color[8]	Flowering Time	Wildlife Value[9]	Excessive Litter[10]
Willow, Black	*Salix nigra*	S	VS	MS	10-30	10-30	EB	E	I		X	

[1]Height class (ground to tip of leader or tallest branch) of a mature tree commonly achieved in urban situations with less than optimal growing conditions. S = Small: 15-25 feet; M = Medium: 25-40 feet; L = Large: 40 feet and taller.

[2]The width of the crown (at its widest point) commonly achieved in urban situations with less than optimal growing conditions. VS = Very Small (150 square feet with a 15 foot crown diameter); S = Small (400 square feet with a 25 foot crown diameter); M = Medium (900 square feet with a 35 foot crown diameter); L = Large (1,600 square feet with a 45 foot crown diameter).

[3]General shape of the tree's crown (leaves and branches). I = Irregular; MS = Multi-Stemmed; O = Oval (Columnar); P = Pyramidal; R = Rounded; S = Spreading; U = Upright (Vase).

[4]Typical range of height of tree in feet from ground to bud at tip of leader or tallest branch under various conditions.

[5]Typical range of spread of branches in feet at the widest diameter across the crown under various conditions.

[6] Persistence and type of leaf on the tree. Deciduous trees lose their leaves in the fall. DB = Deciduous Broadleaf ; DC = Deciduous Conifer; EB = Evergreen Broadleaf; EC = Evergreen Conifer.

Table D-7. List of physical characteristics for tree species suitable for urban and community forestry environments in the Southeast (continued).

[7]E = Evergreen; B = Bronze or brown; M = Maroon; V = Various colors: maroon, red, orange, yellow; O = Orange; R = Red; Y = Yellow; I = Insignificant color change

[8]B = Blue; L = Purple; M = Multiple colors: white, pink, purple, red, or others; P = Pink; R =Red; Y = Yellow; I = Insignificant flowers.

[9] Sp = Spring; Su = Summer; Wi = Winter

[10]Indicates with an "X" if the tree produces flowers (nectar) or fruits that are consumed by insects, birds, or mammals.

[11]Indicates with an "X" if the tree produces large or hazardous leaves, fruit, or other litter.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast.

		Environmental Characteristics and Tolerances									
Common Name	Latin Name	Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Ash, Green	*Fraxinus pennsylvanica*	X	F	M	0.09	W	H	sl ac-sl alk	FS	G/	
Ash, White	*Fraxinus americana*	X	M	M	0.1	M	L	sl ac-sl alk	FS	M/ IS	
Baldcypress	*Taxodium distichum*	X	M	L	0.032	M	H	ac-sl alk	FS	G/	X
Beech, American	*Fagus gradifolia*	X	S	L	0.16	M	L	acidic	FS	P/ A	
Birch, River	*Betula nigra*	X	F	M	0.117	M	L	acidic	PS	G/	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Environmental Characteristics and Tolerances									
Common Name	Latin Name	Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Birch, River 'Heritage'	*Betula nigra 'Heritage'*	X	F	M	n/a	M	L	acidic	PS	n/a	
Blackgum (Tupelo)	*Nyssa sylvatica*	X	S	M	-0.053	M	M	sl ac-sl alk	FS	G/	X
Boxelder	*Acer negundo*	X	F	S	0.036	W	M	adapt	FS	G/	
Catalpa, Southern	*Catalpa bignonioides*	X	F	S	0.014	M	M	sl ac-sl alk	FS	G/	
Cherry, Black	*Prunus serotina*	X	F	M	0.083	M	M	sl ac	FS	M/ I	
Cottonwood, Eastern	*Populus deltoides*	X	F	M	-0.708	M	M	sl ac-sl alk	FS	G/	X
Crapemyrtle, Common	*Lagerstroemia indica*	X	F	M	0.004	M	H	ac-sl alk	FS	n/a	
Dogwood, Flowering	*Cornus florida*	X	M	M	0.021	M	L	ac-nu	PS	M/ IP	
Dogwood, Flow. Pink	*Cornus florida var. rubra*	X	M	M	n/a	M	L	n/a	PS	n/a	
Elm, American	*Ulmus americana*	X	M	M	0.143	M	H	sl ac-sl alk	FS	M/ P	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Environmental Characteristics and Tolerances									
Common Name	Latin Name	Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Elm, Slippery	*Ulmus rubra*	X	F	M	0.086	M	M	sl ac-sl alk	FS	M/ P	
Elm, Winged	*Ulmus alata*	X	M	M	0.034	M	H	sl ac-sl alk	FS	G/	X
Hickory, Bitternut	*Carya cordiformis*	X	F	L	0.069	M	L	acidic	FS	P/ S	
Hickory, Mockernut	*Carya tomentosa*	X	S	L	0.059	D	H	sl ac	FS	MP/ S	
Hickory, Pignut	*Carya glabra*	X	S	L	0.058	M	H	sl ac	FS	M/ S	
Hickory, Shagbark	*Carya ovata*	X	S	L	0.064	M	M	sl ac	FS	P/ S	
Hickory, So. Shagbark	*Carya ovata var. australis*	X	S	L	n/a	M	M	sl ac	FS	n/a	
Holly, American	*Ilex opaca*	X	S	L	0.013	M	H	acidic	PS	G/	X
Holly, Deciduous	*Ilex decidua*	X	M	S	n/a	W	H	ac-alk	PS	G/	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Environmental Characteristics and Tolerances									
Common Name	Latin Name	Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Honeylocust	*Gleditsia triacanthos*	X	F	S	0.009	M	H	sl ac-sl alk	FS	G/	X
Hophornbeam, Am.	*Ostrya virginiana*	X	S	M	0.032	M	H	ac-alk	SH	M/ S	X
Hornbeam, A.	*Carpinus caroliniana*	X	S	M	0.009	M	M	sl ac-sl alk	PS	M/ SC	
Magnolia, Cucumber	*Magnolia acuminata*	X	F	M	n/a	M	L	acidic	PS	M/ I	
Magnolia, Southern	*Magnolia grandiflora*	X	M	L	0.002	M	M	acidic	FS	M/ I	
Magnolia, So. 'Little Gem'	*Magnolia grandiflora 'Little Gem'*	X	S	M	n/a	M	L	acidic	FS	n/a	
Magnolia, Sweetbay	*Magnolia virginiana*	X	F	M	n/a	W	L	acidic	PS	G/	
Maple, Red	*Acer rubrum*	X	F	L	0.084	M	L	sl ac	FS	G/	
Maple, Silver	*Acer saccharinum*	X	F	S	0.084	M	H	ac	FS	P/ A	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Environmental Characteristics and Tolerances									
Common Name	Latin Name	Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Maple, Florida Sugar	*Acer barbatum*	X	M	M	n/a	M	H	ac	FS	M/ IS	X
Maple, Sugar	*Acer saccharum*	X	M	L	0.1	M	M	sl ac-sl alk	PS	pm	
Maple, Su. 'Green Mtn.'	*Acer sach. 'Green Mtn.'*	X	F	L	0.1	M	M	sl ac-sl alk	PS	n/a	
Maple, Sugar 'Legacy'	*Acer saccharum 'Legacy'*	X	F	L	0.1	M	M	sl ac-sl alk	PS	n/a	
Mulberry, Red	*Morus rubra*	X	F	S	0.099	M	H	sl ac-sl alk	FS	G/	
Oak, Black	*Quercus velutina*	X	M	L	0.253	D	H	sl ac	FS	G/	
Oak, Cherrybark	*Quercus falcata*	X	M	L	n/a	M	M	ac	FS	G/	
Oak, Diamond Leaf	*Quercus laurifolia*	X	M	L	n/a	M	M	ac-sl alk	FS	G/	
Oak, Northern Red	*Quercus rubra*	X	F	L	0.503	M	M	ac-sl ac	FS	GM/ S	
Oak, Nuttall	*Quercus nuttalli*	X	M	L	n/a	M	M	ac	FS	n/a	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

Common Name	Latin Name	Environmental Characteristics and Tolerances									
		Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Oak, Overcup	*Quercus lyrata*	X	M	L	0.159	W	M	ac-sl alk	FS	G/	
Oak, Post	*Quercus stellata*	X	M	L	0.327	D	H	ac-sl alk	FS	G/	
Oak, Scarlet	*Quercus coccinea*	X	M	L	0.592	D	H	sl ac	FS	G/	
Oak, Shumard	*Quercus shumardii*	X	F	L	0.265	M	H	ac-alk	FS	G/	
Oak, Southern Red	*Quercus falcata*	X	M	L	0.576	M	H	ac	FS	G/	
Oak, Swamp Chestnut	*Quercus michauxii*	X	M	L	0.544	M	M	n/a	FS	G/	
Oak, Water	*Quercus nigra*	X	F	M	0.451	M	M	ac-sl alk	FS	G/	
Oak, White	*Quercus alba*	X	S	L	0.348	M	M	acidic	FS	GM/S	
Oak, Willow	*Quercus phellos*	X	F	L	0.314	M	H	acidic	FS	GM/S	X
Pecan	*Carya illinoensis*	X	S	M	0.088	M	L	sl ac-sl alk	FS	mg	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Environmental Characteristics and Tolerances									
Common Name	Latin Name	Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Persimmon, Common	*Diospyros virginiana*	X	M	S	0.058	M	H	ac-alk	FS	G/ P	X
Pine, Loblolly	*Pinus taeda*	X	F	M	0.016	M	M	acidic	FS	G/	
Pine, Longleaf	*Pinus palustris*	X	M	L	0.01	M	H	ac-sl alk	FS	GM/ C	
Pine, Shortleaf	*Pinus echinata*	X	M	L	0.008	M	H	ac	PS	GM/ P	
Pine, Slash	*Pinus elliotii*	X	F	M	0.01	M	M	ac-sl alk	FS	G/	
Plum, Chickasaw	*Prunus angustifolia*	X	F	M	-0.415	M	H	sl ac-sl alk	FS	pg	X
Poplar, Yellow	*Liriodendron tulipifera*	X	F	M	-0.417	M	H	ac-alk	FS	n/a	
Redbud, Eastern	*Cercis canadensis*	X	M	L	0.171	M	L	sl ac	FS	P/ IS	
Redbud, E. White	*Cercis canadensis (alba)*	X	F	S	0.012	M	M	ac-sl ac	PS	M/ S	
Redcedar, Eastern	*Juniperus virginiana*	X	M	S	n/a	D	H	ac-sl ac	FS	n/a	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

		Environmental Characteristics and Tolerances									
Common Name	Latin Name	Native Tree to Mississippi	Growth Rate[1]	Average Life Span[2]	Net Effect on Air Quality[3]	Soil Moisture[4]	Drought Tolerance[5]	Preferred Soil pH[6]	Light Requirement[7]	Construction Tolerances/Limitations[8]	Urban Tolerant Tree[9]
Sassafras	*Sassafras albidum*	X	F	S	0.022	M	M	ac-sl alk	FS	G	
Sourwood	*Oxydendrum arboreum*	X	M	S	n/a	D	H	sl ac-sl alk	FS	n/a	X
Sweetgum	*Liquidambar styraciflua*	X	M	M	0.118	M	M	ac	FS	G/I	
Sycamore	*Platanus occidentalis*	X	M	M	n/a	M	L	ac-sl alk	FS	n/a	
Willow, Black	*Salix nigra*	X	M	S	n/a	M	M	ac-alk	FS	G/	

see page 171 for footnotes describing letters used in this table.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

[1]Typical rate of growth under urban conditions. S = Slow: 1/2 to 1-1/2 feet/year; M = Moderate: 1-1/2 to 2-1/2 feet/year; F = Fast: 2-1/2 to 3+ feet/year.

[2]The average life span (useful service life) of the species when growing under average urban conditions. A tree is at the end of its useful service life when its risk of failure becomes unacceptable and cannot be improved or when the tree is no longer an asset due to its appearance or condition. S = Short: less than 25 years useful service life; M = Moderate: 25 to 40 years useful service life; L = Long: 50 years or greater useful service life.

[3]The net monetary effects in cents attributable to the species on air quality; listed as a benefit (positive) or cost (negative). Includes the species net effect on ozone, sulfur dioxide, nitrogen dioxide, particulate matter (PM_{10}), and carbon monoxide.

[4]The typical soil moisture conditions for the species in its native habitat. H = Hydric: wet and may be occasionally flooded for short periods; M = Mesic: moist but moderately well- to well-drained; X = Xeric: dry and very well-drained.

[5]Tolerance of the species to infrequent rain, low soil moisture, full sun, and high temperatures. Low = not tolerant to drought ; Moderate = tolerant to mild drought; moderately tolerant to severe drought; High = very tolerant to mild, severe, and prolonged drought.

[6]Relative soil acidity or alkalinity preferred by the species. In many cases, a range of pH preference is given if it was available. In other cases, a general level is given. A pH of 7.0 is neutral, a pH of less than 7.0 is acidic, and a pH of greater than 7.0 is alkaline. Ac = acidic (5.0 to 6.0); sl ac = slightly acidic (6.0 to 7.0); nu = neutral (7.0); sl al = slightly alkaline (7.0 to 8.0); al = alkaline (8.0 to 8.5); n/a = no information available.

[7]The amount of sunlight the species prefers or will tolerate. Trees that are typically found in the understory or are characteristic of late forest successional stages prefer shade or at least partial shade, while trees that typically form the overstory or are characteristic of early successional stages prefer full sun. FS = Full Sun; PS = Partial Shade; SH = Shade.

[8]The broad tolerance of the species in its home range to construction damage, and the limitations that constrain a species tolerance to damage. Tolerances: P = Poor; M = Moderate; G = Good; Limitations: I = physical injury, wood compartmentalization and decay; P = pest complications, including chronic and acute attacks; S = soil conditions, including aeration and water availability; C = limited climatic tolerances, including native range, hardiness, and micro-climate change; A = all of the limitations described above.

Table D-8. List of environmental characteristics and tolerances for tree species suitable for urban and community forestry environments in the Southeast (continued).

[9]Based upon other characteristics and tolerances to urban conditions; an "X" indicates the species is suitable for planting under "tough" urban conditions.

Table D-9. List of storm resistant tree species recommended for the Southeast (listed in descending order from most to least resistant).

Flood Tolerant	Breakage	Uprooting	Salt
Baldcypress	Live Oak	Live Oak	Live Oak
Pondcypress	Palm	Palm	Palm
Tupelo-gum	Baldcypress	Baldcypress	Sweetgum
Sweetbay Magnolia	Pondcypress	Pondcypress	Water Oak
Willow	Sweetgum	Tupelo-gum	Sycamore
Sweetgum	Tupelo-gum	Redcedar	Baldcypress
Sycamore	Dogwood	Sweetgum	Pondcypress
River Birch	Southern Magnolia	Sycamore	Southern Red Oak
Cottonwood	Sweetbay Magnolia	Longleaf Pine	Southern Magnolia
Green Ash	Southern Red Oak	Southern Red Oak	Tupelo-gum
Red Maple	Water Oak	Southern Magnolia	Sweetbay Magnolia
Pecan	Sycamore	Slash Pine	Hickory
Mulberry	Longleaf Pine	Loblolly Pine	Pecan
American Elm	Slash Pine	Sweetbay Magnolia	Red Cedar
Persimmon	Loblolly Pine	Water Oak	Red Maple
Silver Maple	Red Cedar	Red Maple	Holly
Water Oak	Red Maple	Dogwood	Locust
Swamp Chestnut Oak	Dogwood	Hickory	Persimmon
Southern Magnolia	Hickory	Pecan	Sugarberry

Appendix E – Reduction of Impervious Cover in Urban and Community Areas

Table E-1. Strategies to minimize impervious area at the site development level.*

1. Reduce residential road widths.
2. Shorter road lengths.
3. Cul-de-sac donuts.
4. Disconnect roof leaders.
5. Cluster development.
6. Angled parking.
7. Smaller parking stalls.
8. Reduced parking ratios for some land uses.
9. Shared parking and driveways.
10. Shorter residential driveways.
11. Reduced cul-de-sac radii.
12. Taller buildings.
13. Vertical parking structures.
14. Require open space/green space.
15. Require buffers.
16. Swales rather than curb/gutters.
17. Encourage runon to pervious surfaces.
18. Commercial open space landscaping.
19. Sidewalks on one (lowest) side of street.
20. Reduce setbacks and frontage.
21. Flexible minimum lot sizes.
22. "Hourglass" streets.
23. T or V shaped turnarounds.
24. Permeable spillover parking areas.

*Adapted from PZC, Inc. 19921, Schueler et al. 1991, and Wells 1994.

Appendix F – Additional Urban and Community Forestry Resources

The software, video/DVDs, Web Links, and Educational Materials such as PowerPoint Presentations/Slides and Additional Printed Materials are not intended to be an all–inclusive list. They are merely a sample of the types of information and the media venues by which this information can be accessed.

Software		
Product	Vendor and Address	Notes
ArborAccess	West Coast Arborists 2200 East Via Burton Street Anaheim, CA 92806 (800) 521-3714 info@wcainc.com www.wcainc.com	ArborAccess, is a tree inventory program that simplifies the management of the urban forest and can be linked to a GIS program such as ArcView for geocoding purposes.
ArborPro	ArborPro, Inc. P.O. Box 18071 Anaheim Hills, CA 92817 info@aborprousa.com www.arborprousa.com	ArborPro is a comprehensive inventory program to assist in the efficient management of trees, landscape, and physical assets utilizing GIS technology.
CITYgreen	American Forests P.O. Box 2000 Washington, DC 20013 (202) 737-1944 www.americanforests.org www.americanforests.org/productsandpubs/citygreen	CITYgreen is a powerful GIS application for land-use planning and policy-making. The software conducts complex statistical analyses of ecosystem services and creates easy-to-understand maps and reports. CITYgreen calculates dollar benefits based on your specific site conditions.

Software		
Product	Vendor and Address	Notes
Community and Urban Forest Inventory and Management Program (CUFIM)	Norman H. Pilsbury Samantha J. Gill Urban Forest Ecosystems Institute Cal Poly State University San Luis Obispo, CA 93407 www.ufei.org/files/ufeipubs/CUFIM.zip	CUFIM is an Excel-based computer program that can be used to setup and maintain a tree inventory and database, and to evaluate the urban forest in quantitative terms including volume and value.
ecoSmart	Center for Urban Forest Research, Pacific Southwest Research Station, USDA Forest Service 1 Shields Avenue, Suite 1103 Davis, CA 95616-8587 (530) 752-7636 www.fs.fed.us/psw/programs/cufr/ www.ecosmart.gov	ecoSmart is designed to evaluate the economic trade-offs between different landscape practices on residential parcels. It estimates the impacts of strategic tree placement, rainfall management, and fire prevention practices.
InvenTree	Solutions by Lehman 510 Lincolnway East Mishawaka, IN 46544 (574) 256 9267 chuck@lehmanandlehman.com	Database Inventory program including a set of template files containing preformatted fields, layouts, and scripts designed for inventories and management.

Software		
Product	Vendor and Address	Notes
MCTI – Mobile Community Tree Inventory	USDA Forest Service Northeast Center for Urban and Community Forestry and Parks Department Springfield, MA 01109 www.umass.edu/urbantree/mcti David Bloniarz, USDA-FS dbloniarz@fs.fed.us	The MCTI software has been developed as a desktop and PDA software package that provides a versatile tree inventory collection system for municipal tree managers. This public-domain program package, manual, and associated materials are available for free download and can be used by communities of varying sizes.
Pocket Arborist	Gray Hill Solutions, Inc. 1100 NE 45th Street, Suite 210 Seattle, WA 98105 treepro@grayhillsolutions.com www.treeproworld.com/contact.htm	Pocket Arborist™ gives you three powerful tools for your handheld device: a valuation calculator, a hazard tree assessment system, and a small tree inventory database—all in the palm of your hand.
SelecTree: A Tree Selection Guide	Urban Forest Ecosystems Institute Cal Poly State University San Luis Obispo, CA 93407 www.selectree.calpoly.edu ufei@polymail.calpoly.edu	SelecTree is an interactive program designed to match specific tree species to particular sites based on compatible characteristics.
SilviBASE	Natural Resource Planning Services – David Fox 5700 SW 34th St., Suite 324 Gainesville, FL 32608 (352) 378-8966 davef@nrpsforesters.com	Tree inventory software.

Software		
Product	Vendor and Address	Notes
STRATUM (Street Tree Resource and Analysis Tool for Urban forest Managers)	i-Tree 1500 N. Mantua Street Kent, OH 44240 (877) 574-8733 info@itreetools.org www.itreetools.org	STRATUM is a street tree management and analysis tool for urban forest managers that use tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO2 reduction, stormwater control, and property value increase.
TreeKeeper 7, TreeKeeperOnline	Davey Resource Group 1500 North Mantua Street P.O. Box 5193 Kent, OH 44240 (800) 828-8312 tk7sales@davey.com www.davey.com/treekeeper	TKO is an Internet-based tree inventory program. Features include TreeSites Manager, Work Records Manager, and TreeKeeper Site Finder.
TreeLink	352 S. Denver St., Suite 315 Salt Lake City, UT 84111 (801) 363-3435 www.treelink.org	Information, education and communication related to urban forestry. Funded by a major grant from the National Urban and Community Forestry Advisory Council (part of the USDA Forest service), TreeLink will provide a rich and flexible set of resources for the urban forestry community. Their goal is long-term impact in cities and towns, where the great majority of the public live.

Software		
Product	Vendor and Address	Notes
TreeMaster	Urban Forestry Consultants 4980 Aspian Way, Suite 205 El Sobrante, CA 94803 (510) 222-1946 tpehrson@pacbell.net	Street-tree inventory software
TreeScape	Natural Resource Technologies, L.L.C. P.O. Box 780603 Tallassee, AL 360778 (888) 848-2146 info@nrtech.com www.nrtech.com	TreeScape is a Geographic Information System that allows the user to create and print job site maps to scale, maintain information on individual property features (e.g., boundary, beds, turf, trees and hardscape) and to perform queries.
TreeTown	Tom Gaman East-West Forestry Associates, Inc. P.O. Box 276 Inverness, CA 94937 (415) 669-7100 tgaman@forestdata.com www.forestdata.com	TreeTown2000 is a powerful, yet easy to use, tool for collecting, managing, and analyzing Urban Forest data…and mapping Urban Forests anywhere!
TreeWorks	The Kenerson Group 2342 Main Street Athol, MA 01331 (978) 249-6495 info@kenersongroup.com www.kenersongroup.com	The TreeWorks system allows users to build their tree inventory, update it on a regular basis, and provides management tools to plan and track maintenance work, calculate appraised values, analyze and visualize data, and produce maps and reports.

Software		
Product	Vendor and Address	Notes
Trims Tree Inventory	TRIMS Software International, Inc. 8987 W. Olive, #117, PMB 68 Peoria, AZ 85345 (800) 608-7467 info@trims.com www.trims.com	TRIMS Tree Inventory provides a complete tree inventory, tree care and work tracking system for large grounds areas, golf courses, parks, and business campuses. Maintains accurate records of tress, work schedules, work requests, and completed work activities.
UFIS (Urban Forest Inventory System)	Natural Resources Technologies, LLC P.O. Box 780603 Tallassee, AL 36077 (888) 848-2146 info@nrtech.com www.nrtech.com	UFIS is a user-friendly Geographic Information System designed for urban professionals. It allows you to locate trees on a map, edit information about that tree, print work orders, and perform searches.
UFORE (Urban Forest Effects Model)	i-Tree 1500 N. Mantua Street Kent, OH 44240 (877) 574-8733 info@itreetools.org www.itreetools.org	UFORE is a model that allows users to collect data on the entire urban forest and estimate the ecosystem services the resource provides to the community.

Web Links

Alabama Forestry Commission	www.forestry.state.al.us
American Forests	www.americanforests.org
Community Trees	communitytrees.org
Firewise	firewise.org
Georgia Forestry Commission	www.GaTrees.org
International Society of Arboriculture	www.isa-arbor.com
Mississippi Forestry Commission	www.mfc.state.ms.us/u&cf.htm
Mississippi Institute for Forest Inventory	www.mifi.ms.gov
Mississippi Urban Forest Council	www.msurbanforest.com
National Arbor Day Foundation	www.arborday.org
National Urban and Community Forestry Advisory Council	www.treelink.org
Southern Regional Extension Forestry	www.sref.info
Southern Urban Forestry Associates	www.sufa.com
Tree Link	www.treelink.org
United States Forest Service, Southern Research Station	www.srs.fs.usda.gov
Urban and Community Forestry	www.fs.fed.us/ucf
Urban Forestry Index	www.urbanforestryindex.com
Urban Forestry South Expo	www.urbanforestrysouth.org

Educational Materials - Videos		
Title	**Source**	**Notes**
From Sketch to Street: Design for the Urban Forest Part One	USDA Forest Service - Northeastern Area	This video explains the necessities of design and planning involved in urban forestry. It is split into eight sections: Introduction, Designing a Streetscape, Avoiding Power Line Problems in Developments and Along New Roads, Designing Downtown, Avoiding Other Utilities, What to Plant, Choosing the Correct Species, and Final Words. The overall goal is to demonstrate how to make trees an asset to the community as opposed to an obstacle that must be tackled. The video has good animated graphics and a modern feel.
Trees For Your Home: A Reference Guide To Growing Healthy Trees	Alabama Urban Forestry Association P.O. Box 812 Auburn, AL 36831-0812 www.aufa.com	A reference for anyone with a question or interest in planting and maintaining trees. Whether you're doing the work yourself or planning to hire a professional, this booklet gives answers to many questions on caring for your trees. You'll also find references to other resources for more in-depth information.

Educational Materials - Videos		
Title	**Source**	**Notes**
Urban Forestry: Making Trees Work for Your Community	Alabama Urban Forestry Association P O Box 812 Auburn, AL 36831-0812 www.aufa.com	Provides compelling reasons for communities to develop technical-based tree programs.
Natural Resource Management in the Urban Forest	Arkansas Forestry Commission 3821 W. Roosevelt Rd. Little Rock, AR 72204-6396 www.forestry.state.ar.us	Managing trees in the urban area.
Effects of Construction Damage to Trees in Wooded Areas	International Society of Arboriculture P.O. Box 3129 Champaign, IL 61826 (888) 472-8733 https://secure.isa-arbor.com/store/Videos-C9.aspx	This video discusses a tree's functions above and below ground. Offers invaluable advice to arborists on working with landowners and contractors to save trees when building on or adding to a structure.
The Value of an Urban Tree – November 2005	The National Urban and Community Forestry Advisory Council 1400 Independence Avenue, S.W. Mailstop 1151 Washington, D.C. 20250-1151 (202) 205-1007 www.treelink.org/nucfac/multimedia.html	A two-part video that discusses the value of urban trees.

Educational Materials - Videos		
Title	**Source**	**Notes**
Tree City USA: Greening America	The Arbor Day Foundation 100 Arbor Avenue Nebraska City, NE 68410 (888) 448-7337	This VHS video introduces the Tree City USA program and how it works to keep urban trees healthy and abundant by creating an annual action plan to plant and prune the city's trees, and to monitor their health.
Xeriscape-Landscaping for Today and Tomorrow	National Xeriscape Council P.O. Box 163172 Austin, TX 78716-3172	Discusses landscaping techniques that do not require supplemental irrigation.
Pruning: How to Harvest a Tree	Oklahoma Tree Bank Foundation 16301 N. Rockwell Building A Edmond, Ok 73013 (405) 330-4701 (405) 330-5415 treebankok@msn.com okplanttrees.okstate.edu/resources/videos/	A number of videos are available at this Web site covering a diverse set of topics offered by a number of organizations.

Educational Materials - Videos		
Title	**Source**	**Notes**
Urban Forestry Video Resources	Urban Forestry Working Group Wisconsin DNR 101 S. Webster Street P.O. Box 7921 Madison, Wisconsin 53707-7921 . (608) 266-2621 www.urbanforestrysouth.org/resources/library/urban-forestry-video-resources/view?searchterm=None	Describes over 50 U&CF videos with information on content, audience, length and availability.
Forestry Videos – Urban Forestry and Arboriculture	Southern Regional Extension Forestry Room 433 Forestry Building 4 University of Georgia Athens, GA 30602-2152 (706) 542-7813 www.sref.info www.forestryvideos.net	This site contains a collection of 29 videos covering a variety of topics such as plant health care, managing urban soils, and construction damage.
Trees are Cool	Trees are Good International Society of Arboriculture P.O. Box 3129 Champaign, IL 61826-3129 www.isa-arbor.com http://www.treesaregood.com/other/imageLibrary/video.aspx?ID=PSA1	A video on the same topic.

Educational Materials - PowerPoint Presentations/Slides		
Title	**Source**	**Notes**
Selecting Quality Trees from the Nursery	Edward F. Gilman Department of Environmental Horticulture, University of Florida hort.ifas.ufl.edu/woody/powerpoints.htm	A review of the selection of quality trees from a nursery. It details what characteristics you should look for when purchasing quality trees. 42 slides and text.
Pruning Shade Trees in the Landscape	Edward F. Gilman Department of Environmental Horticulture, University of Florida hort.ifas.ufl.edu/woody/powerpoints.htm	The presentation covers basic tree structure; removing branches and reducing branches; structural pruning techniques; reducing, raising, thinning, and cleaning the canopy; what pruning is recommended on a variety of trees; and palm pruning. 157 slides and text.
Urban Design to Accommodate Trees: Introduction	Edward F. Gilman Department of Environmental Horticulture, University of Florida hort.ifas.ufl.edu/woody/powerpoints.htm	This presentation discusses site evaluation, species selection, formula for success, and roots/hardscape conflicts. 45 slides and text.
Urban Design to Accommodate Trees: Sidewalk Solutions	Edward F. Gilman Department of Environmental Horticulture, University of Florida hort.ifas.ufl.edu/woody/powerpoints.htm	This presentation discusses solutions to tree and sidewalk conflicts. 69 slides and text.

Educational Materials - PowerPoint Presentations/Slides		
Title	**Source**	**Notes**
Urban Design to Accommodate Trees: Parking Lot Solutions	Edward F. Gilman Department of Environmental Horticulture, University of Florida hort.ifas.ufl.edu/woody/powerpoints.htm	This presentation discusses solutions to tree and parking lot conflicts. 73 slides and text.
Urban Trees and Shrubs, Section 1: Selecting Deciduous Trees for Urban Areas	Northeastern Area, S & PF USDA Forest Service 1992 Folwell Ave St. Paul, MN 55108 www.na.fs.fed.us/spfo/pubs/uf/uts/index.htm	A review of deciduous tree species that can thrive in typical urban environments; their particular characteristics, relative hardiness, and best uses. 118 slides and text.
Urban Trees and Shrubs, Section 2: Selecting Deciduous Shrubs for Urban Areas	Northeastern Area, S & PF USDA Forest Service 1992 Folwell Ave St. Paul, MN 55108 www.na.fs.fed.us/spfo/pubs/uf/uts/index.htm	A review of deciduous shrub species suited to urban landscape uses and conditions, including information on hardiness and ornamental features. 72 slides and text.
Urban Trees and Shrubs, Section 3: Selecting Conifers for Urban Areas	Northeastern Area, S & PF USDA Forest Service 1992 Folwell Ave St. Paul, MN 55108 www.na.fs.fed.us/spfo/pubs/uf/uts/index.htm	A review of conifer characteristics, genera, and growth habits, including recommendations for urban landscapes uses. 75 slides and text.

Additional Printed Materials

Alabama Urban Forestry Association. (date unknown). Trees For Your Home: A Reference Guide To Growing Healthy Trees. Arkadelphia Road, Birmingham, AL. http://www.aufa.com.

Dicke, S. and B. Hubbard. 2008. Tree Protection Standards in Construction Sites. Cooperative Extension Service and Mississippi Forestry Commission. Jackson, M. 23 pp.

Duryea, M.L., E. Gilman, and E. Kampf. 2007. Urban Forestry Hurricane Recovery Program: An Educational Toolkit. University of Florida, Gainesville Florida. IFAS Extension. http://treesandhurricanes.ifas.ufl.edu.

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