CLIMATE CHANGE AND HISTORIC TREES:

ADAPTIVE STRATEGIES FOR LAND MANAGERS

by

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(Under the Direction of Shelley Cannady)

ABSTRACT

Climate change is affecting and will continue to affect our culturally important landscapes. To protect these cultural resources, land managers need to prepare preservation and treatment plans to ensure the preservation of our outdoor heritage. Climate change variables such as temperature change, precipitation change, hardiness zone shifts, pest and disease outbreaks, and phenology changes are discussed in relation to their potential impacts on cultural landscapes, particularly trees. Using a culturally important streetscape in Athens, GA, as a case study, this paper makes general and specific recommendations for preparing for unknown climate futures.

INDEX WORDS: climate change, cultural landscape, historic tree, landmark tree, dogwood, adaptive management, tree ordinance, historic landscape, landscape preservation

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CHAPTER 1

INTRODUCTION

Climate change will affect not only the range of tree species in natural forests, but also tree species in the built environment. Land managers need to assess the present and potential impacts of climate change to provide recommendations for tree maintenance and potential replacement. Sites with historic or culturally important streetscapes or plantings are particularly sensitive, as the potential loss or decline of these trees could cause changes in the feeling, association, and material composition of these landscapes. Trees are the wall and roof of our outdoor architecture and their presence greatly affects our sense of place. How can land managers use climate forecasting and tree species characteristic information to make informed decisions about the treatment of historically significant trees?

The purpose of this study is to generate recommendations for the treatment or management plans for historic trees. Expanding upon the framework of the cultural landscape report (CLR) developed by the National Park Service, additional tools and considerations provide flexibility for land managers to adapt their plans under climate change scenarios. Most present treatment or management plans need minimal updates to allow for our changing climate. Many of these additional tools are already in use by current land managers. However, culturally significant resources that are still unrecognized may have no management plan in place to protect them, and these recommendations provide a starting point for plan development and implementation.

Much research exists on the effects of climate change on trees in natural environments. There is also an abundance of research on the effects of climate change on urban areas. However, there is little research on the effects of climate change on existing urban trees, particularly historic trees. Trees planted in urban conditions face a high number of stressors not found or rarely found in natural environments: examples include soil compaction, limited root zones, higher temperature stress from urban heat island effect, high urban soil contaminant levels, and increased wind exposure from urban wind tunnels. In addition, much nursery tree stock is cultivated by cloning, resulting in lower genetic diversity for urban trees (Sanders 1981). This decrease in genetic diversity puts urban trees at risk of decimation from climate change effects.

In Chapter 2, the ecological, economic, and sociocultural benefits of trees are discussed. To make an argument for preserving our urban forests, many aspects of their contributions to our lives are examined. Given the range of ecosystem services provided by trees in urban landscapes, urban forests are critical to the creation and maintenance of healthy urban ecology. Trees contribute to the economy of our cities by making urban landscapes more desirable as places to live, work, and spend money. Our sociocultural values are influenced by urban trees by means of place-making, memory-making, and positively influencing human behavior. The aesthetic value of urban trees defines sense of place and increases feelings of environmental responsibility toward urban landscapes.

Climate change is a topic at the forefront of scientific study and public debate. Chapter 3 discusses the causes and potential effects of climate change. Climate change variables such as changes in temperature, precipitation, and sea level rise are explained in relation to their effects on trees. A basic understanding of climate trends is necessary to demonstrate the need for

planning for climate change now. Land managers, especially of historic landscapes, need to understand the full potential for change and loss in their landscapes.

Trees in urban environments are always at risk of removal due to the dynamic nature of urban development. Chapter 4 examines what general protections are available for historic trees including National Register of Historic Places (NRHP) designation and local tree ordinances. A brief overview of the NRHP explains how trees may be federally recognized as part of historic sites. The idea of cultural landscapes is explained and management treatment options for these landscapes are explored. Local tree ordinances are discussed in terms of how they may define and protect historic trees.

To demonstrate the specific ways that historic trees may be at risk due to climate change, Chapter 5 introduces the Prince Avenue flowering dogwoods in Athens, GA, as a case study. The intent of this study is to highlight the potential outcomes for historic trees under climate change scenarios. This particular historic landscape was selected for multiple reasons. It is a highly accessible landscape experienced by a variety of users on a daily basis, mostly drivers and pedestrians. Given its high visibility as an urban streetscape along a busy corridor, its loss would be observable by a large number of people. This is a vernacular landscape developed not through a formal or professional design, but by community tradition and aesthetics. The trees in this landscape would be affected similarly by climate change, given that they are mostly the same species planted under similar urban conditions. The plantings are of various ages and health conditions, and have been replaced and augmented during multiple city beautification efforts by multiple stakeholder groups. Due to this variety of age and condition, it is unlikely that they would all need replacement at the same time under current conditions. This provides an interesting perspective, as many trees in historic landscapes are single specimen plantings that

will eventually die and need replacement no matter how well their maintenance program is planned and executed. The loss of the flowering dogwoods along the Prince Avenue corridor would eliminate a more than mile-long streetscape and would end an aesthetic tradition begun over fifty years ago.

In conclusion, Chapter 6 suggests additions to the cultural landscape report framework to allow it to remain relevant for climate change scenarios. The first important step to save our historic trees is recognition of them as an important resource. If land managers have not already set preservation goals for these resources, this should be their next step. Management plans or treatment plans should include flexible options for managing historic trees, should they become threatened. Monitoring, maintenance, and updating adaptive strategies are important actions for preserving our historic resources. The recommendations covered in this chapter are general and not all-inclusive. Historic landscapes are diverse in their significance and integrity, and treatment plans tailored to each specific site are necessary for proper management. Specific adaptive plans to maintain or eventually replace the Prince Avenue dogwoods are addressed at the end of the chapter. These too are very general and serve to only to demonstrate that an array of options may be appropriate in any given historic landscape. More specific plans or refinements of these plans are best formulated by the land managers and stakeholders of this important cultural resource.

CHAPTER 2

VALUE OF THE STUDY

Trees provide myriad benefits in the urban environment. Numerous studies have quantified and qualified these known benefits. These studies, as well as ongoing research, demonstrate the importance of our urban forests as they relate to ecology, economy, culture, and society. As the density of urban centers continues to increase worldwide, and development space becomes even more limited, advocating these values of trees will be necessary to justify their installation, preservation, and continued maintenance. Advocating for the identification and preservation of culturally or historically important trees will assist in supporting the cultural continuity of our landscapes in an ever-changing environment. The value of trees must be continually recognized and reinforced in order save our urban forests and all of the benefits provided by them.

Trees contribute to the ecological processes of urban environments in various ways. Mature trees serve as energy savers by providing shade, thereby reducing the amount of energy needed to cool buildings. Trees strategically planted on the west and south sides of buildings, as well as near cooling equipment, result in significant energy use reduction. Shade provided by trees reduces urban heat island effects, including the reduction of urban summer temperatures by 20° on sites with trees. Evapotranspiration contributes to heat dissipation, providing additional cooling benefits. Trees provide a significant buffer for wind control. This results in up to 15% lower heating costs due to the decrease of cooling winds during cold months (Coder 1996).

Urban forests provide both air and water cleansing benefits. Urban trees are filters for both pollutant gases and particulate matter. They absorb excess carbon dioxide and individual trees can release enough oxygen to supply 18 people per day (Coder 1996). Other contaminants processed by urban trees include nitrogen oxides, sulfur dioxides, and carbon monoxide. Areas with tree cover are more capable of processing urban pollutants, thereby reducing water and air contamination.

Urban trees are critical for erosion control and stormwater management. Tree roots absorb water from rain events, thereby reducing erosion caused by unchecked run-off. Leaves and branches reduce the volume and velocity of rainfall as it reaches the ground. Trees also filter nutrients and pollutants before they enter stormwater systems and waterways. With their extensive root systems, trees contribute to soil stabilization, further reducing erosion. In areas cleared of trees, topsoil and surface organic matter quickly erode away, increasing sedimentation in waterways.

In addition, urban forests provide habitat for many kinds of wildlife. Birds, insects, and small mammals use trees for shelter, as well as a source of food. These trees may form corridors that connect larger habitats for these animals. Some urban forests are large enough to provide sufficient patch habitat for flora and fauna (Zipperer et al. 1997). Urban trees create soil surface and subsoil habitat for a variety of microorganisms. Loss of natural habitat from development is the leading cause of species endangerment and extinction. Human populations reap a variety of health and psychological benefits created by tree canopy habitat.

Urban trees contribute to the economy of cities. Economic values of urban trees include building energy savings, increased property values, and increased revenues from tourism (Wolf 2005). Shade provided by trees decreases building energy costs, especially when mature trees are

on the west and south sides of buildings (Coder 1996). Trees help buffer strong winds from storms, which minimizes building damage, especially reducing shingle replacement repairs (Peterson and Straka 2011). Wind buffering also reduces energy costs during cold months by blocking chilling winds.

The presence of trees positively influences land values. Real estate values of parcels with some tree cover are higher than parcels with few or no mature trees (Anderson and Cordell 1988). Urban forests with low density contribute to community aesthetics, which has a direct economic impact on local businesses and property values. Ongoing studies conducted in Chicago demonstrate that the ecosystem services provided by trees outweigh the costs of maintaining trees by more than double over the course of the life of the tree (McPherson et al. 1997). Large tree removal is a considerable expense, and replanted trees will not provide significant energy savings until they reach maturity. Many areas see an increase in tourism during the fall season when autumn foliage color is at its peak, as demonstrated by a public awareness study conducted in Vermont to assess residents' views of state forests (O'Brien 2006).

Sociocultural values of trees can be divided into areas of memory, behavior, and aesthetics. People have strong emotional ties to trees and forests because of their association with places and loved ones (Dwyer et al. 1991). Trees speak to our collective memories; their great ages and vast sizes serve as reminders of our cultural and natural history. We associate the changing of the seasons with plant phenology. Trees and vegetation contribute to the creation of a sense of place and time through the activation of all senses (Hunter 2008).

Studies have shown that the presence of trees positively influences human behavior. Urban forests provide a link to nature for city dwellers, which has measurable psychological benefits (Dwyer et al. 1991; Lawrence 1995). Creativity and cognitive ability are stronger in

children who play in natural, unprogrammed environments (Louv 2008). People in confinement, such as hospital patients and prisoners, show less signs of stress and have better health results when green landscapes are visible from their windows (Ulrich 1984). Studies have shown that people have better relationships with their neighbors and a stronger sense of community, resulting in lower crime rates, when trees are present in their immediate environment (Sullivan and Kuo 1996).

Aesthetic value contributed by urban trees creates places that humans want to occupy (Lawrence 1995). Beautiful landscapes can create transformative experiences for users (Meyer 2008), and they encourage people to develop feelings of attachment and responsibility for their environment. The spatial arrangement and species selection of trees and vegetation in a given area inform people how they are supposed to interact with built environments by providing them with contextual information. For example, a hedgerow of Chinese holly indicates that an area is off-limits, whereas an allée of trees indicates a path. Although aesthetics are frequently overlooked in studies, perceived beauty is an invaluable benefit to landscape users and managers.

All benefits of trees can be related to positive effects on human behavior and perception (Table 2.1). These effects clearly justify the need for trees in human environments.

Table 2.1 Identity effects of trees as seen in different lines of research excerpted from *Trees and Human Identity* (Sommer 2003).

Factor	**Examples**
Physical factors	Tree canopy affects air quality, temperature, wind speed, noise, water water runoff, and other natural processes that may influence human health and well-being

Aesthetic factors	Trees make homes and neighborhoods more desirable, thereby enhancing individual and community self-images. Conversely, tree loss can produce grief responses, reflecting a diminution of self
Economic factors	Trees add to the value of homes and neighborhoods, and this has a positive effect on self-image
Social factors	The presence of trees can improve neighborhood interaction. People identify more with trees they have planted themselves. Organized planting and maintenance programs lead to individual and collective empowerment
Psychological factors	In both self-report and physiological studies, contact with greenery has restorative value. This can restore equilibrium to a person's relationship to the natural environment and heal a damaged self

CHAPTER 3

CLIMATE CHANGE

Climate change is a certain fact of our present and future. Studies have demonstrated that current trends in temperature increases, icecap melt, and sea level rise are related to human activities. Aspects of climate change such as increased precipitation, drought, temperature increases, habitat reduction, range and zone shifts, and sea level rise must be evaluated to determine the possible scenarios that will affect our natural and built environment resources. As caretakers of the built environment, land managers must assess resources, if they have not already, and create a plan for dealing with the implications of climate change. Cultural and historic landscapes are of particular importance with consideration to climate change, as changes in their features may permanently alter their significance. In order to understand the trends and variables implicated by climate change, a brief overview of the causes and present and potential effects of this phenomenon will be discussed.

During the past 100 years, Earth has undergone an unprecedented increase in surface temperature of 1.4°F (Committee on America's Climate Choices 2011). The release of CO_2 and other greenhouse gases has been determined to be the cause for most of the global warming that has occurred during the last five decades (Committee on America's Climate Choices 2011). Fossil fuel emissions, coupled with deforestation, account for this increase in CO_2 released into the atmosphere. Establishing direct links between human activity and temperature increases is often difficult due to regional changes that do not reflect current global trends. However, scientific analysis shows that long-term warming trends cannot be explained by accounting for

typical climate variability factors. This increase in temperature is at least partially accountable for rising global average sea levels, widespread melting of ice sheets and glaciers, thawing of permafrost, and decreases in snow cover and sea ice. In the United States, average air temperature has increase by more than 2° F in the last 50 years (Committee on America's Climate Choices 2011).

Evidence suggests that recent warming patterns are affecting many floras by influencing earlier bloom times, migration, and shifts in species ranges. Temperature increases are also believed to influence disease and pest outbreaks, as well as increase wildfires, although other factors contribute to these phenomena as well (Pachauri and Reisinger 2007). Plant zones worldwide have already begun to shift as a result of temperature increases (Hunter 2008). In 2012, the U.S. Department of Agriculture released a new plant hardiness zone map, showing considerable zone shifts from the previous map release in 1990 (Figures 3.1 and 3.2). One study suggests that this new zone map, based on mean annual temperatures, may be an underestimation of changes in zone shifts which are potentially affected more by annual minimum temperatures (Krakauer 2012). In a study performed by Iverson and Prasad, predictive models indicated that climate change may significantly alter the habitat for tree species in the U.S. For example, the predicted range for the sugar maple (*Acer saccharum*) will shift severely northward, possibly even north of the United States (Iverson and Prasad 2002). In addition to range shifts, some tree species are particularly susceptible to precipitation changes, insect infestations, and diseases that may be influenced by climate change. Already, several diseases and pest outbreaks are decimating tree species, such as the mountain pine beetle that is attacking lodgepole pine (*Pinus contorta*) in the western United States. One study concluded that the northward expansion of the range of the mountain pine beetle is directly affected by climate change (Cudmore et al. 2010).

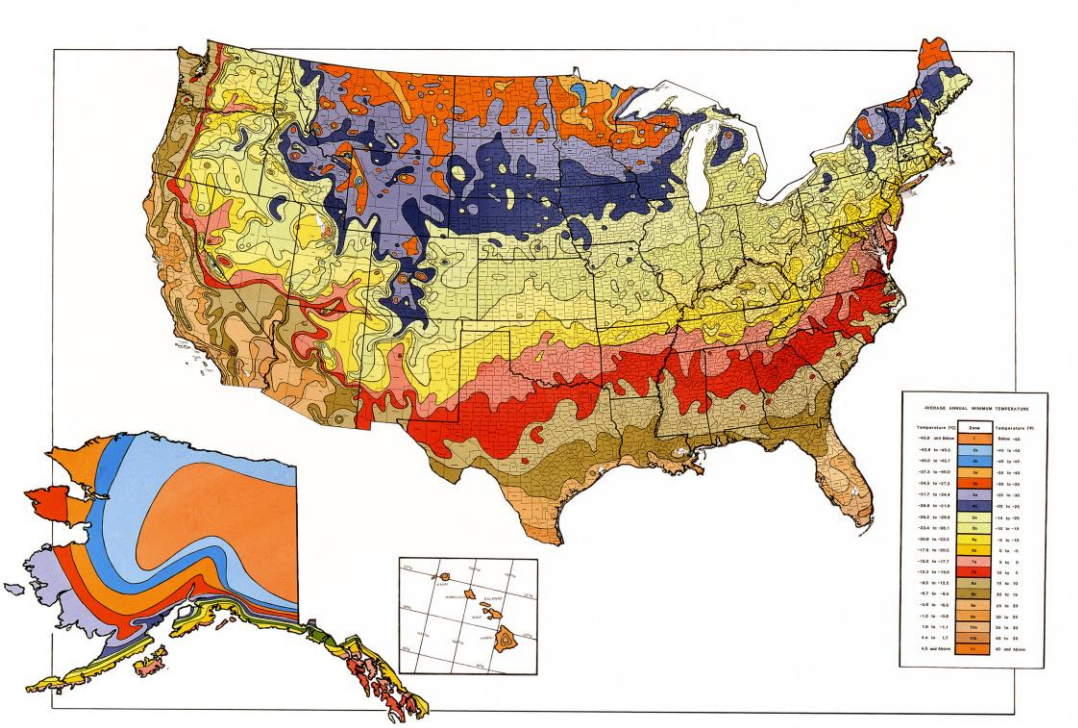

Figure 3.1: USDA Plant Hardiness Zone Map 1990, http://planthardiness.ars.usda.gov.

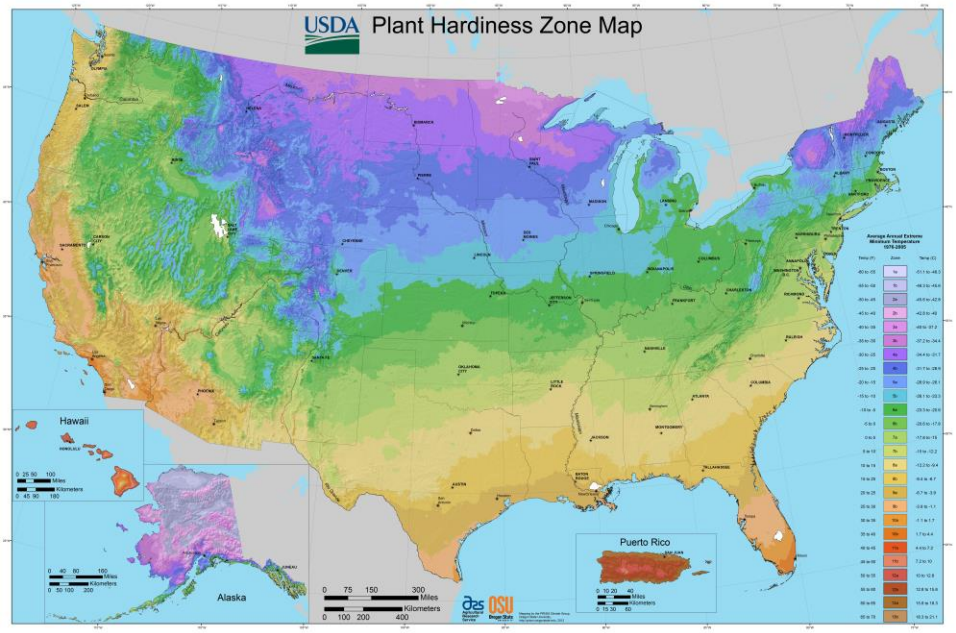

Figure 3.2: USDA Plant Hardiness Zone Map 2012, http://planthardiness.ars.usda.gov.

Climate change is already influencing precipitation patterns that vary from locale to locale. Some areas are experiencing increases in precipitation, and some are experiencing drier conditions or drought (Melnick 2009). Changes in the intensity and frequency of severe weather events has been observed over the last 50 years (Pachauri and Reisinger 2007). These severe weather events have an impact on precipitation in regions where occurrence is more frequent, such as coastal areas. These fluctuations in precipitation will influence plant species' ability to survive in their current habitats. With regard to cultural landscapes, precipitation levels may also alter site hydrology, which could negatively impact cultural and archaeological resources (Melnick 2009). Environmental moisture levels affect some plant diseases, such as dogwood anthracnose. This fungus attacks the flowering dogwood (*Cornus florida*), and is devastating in areas in the southeastern United States where moisture levels and shade cover are high (Holzmueller et al. 2006). Increase in moisture levels caused by precipitation changes could potentially cause this fungus to devastate additional dogwood populations.

Sea level rise is another result of climate change. Increasing temperatures are melting polar ice and glaciers, resulting in rising ocean levels. Many coastal animal and plant communities will be affected by this change in water level that could result in habitat loss or increased salinity of existing habitat. Sea level rise is a threat to human populations as well. In the United States, an estimated 53% of the population lives in coastal areas (Crosset 2005). Coastal cities with eroding shorelines stand to incur the damage or loss of existing structures and infrastructure. Cultural and historic landscapes in coastal areas are at risk of losing resources, especially archaeological resources that may be lost to encroaching water levels.

The ultimate conditions brought about by climate change are unknowable. In the southeastern United States, even though it is generally concluded that average temperatures will

continue to rise, precipitation is affected by so many potential variables that a useful precipitation model is currently not achievable (Seager et al. 2009). However, data collection and predictive modeling aim to provide scientists and land managers with a range of possible climate change scenarios that may be applicable to a variety of outcomes. Agencies worldwide, such as the Intergovernmental Panel for Climate Change and the Committee on America's Climate Choices, are working to provide management frameworks for professionals to use in making decisions regarding climate change issues. The time to formulate guidelines to inform land managers on the range of options to evaluate and manage cultural and historic resources is already here. Robert Melnick, a professor at the University of Oregon, proposes a series of potential actions available to cultural land managers to assist them in making sound decisions. His recommendations are to accept uncertain, variable futures for landscapes, to find ways to adapt to change as well as ways to mitigate it, to engage in practices which promote resilience to change, and to prepare for making difficult decisions about the importance and feasibility of saving particular landscapes for perpetuity (Melnick 2009). These recommendations, used in conjunction with landscape observation and predictive modeling, form a sound basis for decision-making regarding cultural and historic landscapes.

CHAPTER 4

PROTECTION FOR HISTORIC TREES

Despite our knowledge of the benefits of trees, protection for historic trees, much like protection for historic buildings or properties, is limited in scope. The National Register of Historic Places (NRHP) offers recognition for historic resources that may include historic trees, but the legal protection of these resources on non-federally owned properties lies mainly with local historic preservation offices or municipal governments. Historic property inventories often focus on structures and buildings, omitting vegetation. In municipalities that have adopted tree ordinances, trees may have some level of protection, but violations of these ordinances can be difficult to enforce. For a better understanding of how these types of protections may assist in the preservation of historic trees, a brief discussion of the NRHP and typical city tree ordinances follows.

NRHP and Local Historic Designation

The National Historic Preservation Act of 1966 established the NRHP to encourage the preservation of our nation's historic resources. This legislation gives authority to the U.S. Secretary of the Interior to identify and recognize properties of national, regional, and local significance (Tyler 2000). This legislation, however, does not provide guidelines or authority to penalize businesses or individuals who destroy or damage historic property. For historic trees to receive NRHP status they must be nominated by their State Historic Preservation Office (SHPO) or other approved state process and have their nomination approved by the Secretary of State. In

order for a resource to be considered for nomination, the NRHP requires that the following criteria be established: “being associated with an important historic context” and “retaining historic integrity of those features necessary to convey its significance” (Savage and Pope 1998). Historic nomination classifications are buildings, structures, objects, sites, or districts. The two classifications available for protecting historic trees are sites or districts. Typically, local preservation designations use NRHP criteria when nominating local historic resources and developing treatment plans.

In recent decades, the National Park Service (NPS) has realized that significant landscapes are often difficult to categorize and define using the provided NRHP criteria. In 1994, NPS published Preservation Brief 36: Planning, Treatment and Management of Historic Landscapes to assist in defining and providing guidelines for the treatment of cultural landscapes. A cultural landscape is defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values (Birnbaum 1994)." This brief delineates the steps for identifying, researching, documenting, and managing a variety of cultural landscape types and acknowledges the need for preserving non-traditionally defined historic sites as part of maintaining a continuity of our cultural heritage. The clarification of criteria for cultural landscapes recognizes vegetation as an integral component for site inventories and management plans. Because of the dynamic nature of vegetation, however, determining the significance of historic trees requires additional research and a solid management plan to ensure that their historic integrity is retained.

The basic treatment plans for cultural landscapes recommended by NPS are the same as the treatment plans for any historic properties. These treatments are preservation, rehabilitation,

restoration and reconstruction. Land managers should choose an appropriate treatment option based on historic research, potential use objectives, and available funding and support. A treatment plan should be developed for the site or district and documented as part of a general management plan (GMP), cultural landscape report (CLR), or other approved document. Although a treatment plan does not guarantee the protection of historic landscapes, it does provide agreed-upon guidelines for property managers concerning the future use and maintenance of historic resources. Definitions for the four treatment plans are as follows:

> *Preservation* is defined as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.
>
> *Rehabilitation* is defined as the act or process of making possible a compatible use for a property through repair, alterations,and additions while preserving those portions or features which convey its historical or cultural values.
>
> *Restoration* is defined as the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period. The limited and sensitive upgrading of mechanical,

electrical and plumbing systems and other code-required work to make properties functional is appropriate within a restoration project.

Reconstruction is defined as the act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location (Birnbaum 1994).

Period/periods of significance, design intent, design implementation, and changes in land use as well as other issues provide unique challenges to the preservation and maintenance of vegetation in cultural landscapes. Determining the period/periods of significance for cultural landscapes requires careful research. If *preservation* is the recommended treatment for historic properties, accepting the accumulation of landscape changes over the life of the property is necessary regardless of the determined periods of significance. To depict accurately the period of significance, preserved landscapes must currently retain the significant features and integrity of the landscape during this period. *Rehabilitation* is often a desirable option for landscapes, as it allows for new, compatible uses of the property giving flexibility for potential uses. *Restoration* requires thorough documentation of the determined periods of significance to return the landscape to its condition during this time. Often current patterns of land use have altered the spatial arrangement of vegetation in a historic landscape. Changes in circulation, grading, and structural additions to a landscape alter the placement and condition of vegetation and other features. A new driveway or road widening project, for example, may require the removal of trees and shrubs to allow for modern automobiles. The lifespan of plant material may require the replacement of historic vegetation that brings about its own set of challenges. Historic plant

varieties may no longer be available from local nurseries, past and present property owners may have replaced historic material with different vegetation, historic vegetation may have not been replaced at all, or historic vegetation may have proven to be difficult to maintain in terms of location of the planting, pest management, or the intent of the design. *Reconstruction* of a landscape also requires diligent research to determine exactly what landscape features were present during the determined period of significance in order to replace and replant the site according to its history.

A recent issue with cultural landscapes involves a proposed alteration in landscaping at the University of Virginia (UVA). The campus' famous Rotunda building, designed by Thomas Jefferson and completed in 1826, is currently in need of structural repairs. The building is part of the designated NRHP UVA historic district. In the 1920s, a group of southern magnolias was planted in close proximity to the building. The original landscape plan did not include the magnolia trees. Now due to the anticipated repairs on the building, university architects are recommending the removal of the trees as they potentially pose a hazard to workers. A large student and community protest has emerged, as people recognize these trees as a valuable, integral part of the Rotunda landscape. Other professionals support the decision to remove the trees based on legitimate premises. Several of the trees are in poor condition and require support cables to hold the crowns together. Some scholars support their removal, as the magnolia trees were not part of the original landscape plan designed by Jefferson and conflict with his design philosophies (Stack 2012). This dispute could be more easily resolved if a treatment plan including landscape features were already in place for the Rotunda landscape. A period of significance would be firmly established and could be used to determine whether the trees should be removed/replanted.

Tree Ordinances

Tree ordinances can establish protection for historic and culturally important trees. Many cities and counties draft tree ordinances as a way to manage their urban forest resources in regards to planting, maintaining, and removing trees. Tree ordinances provide a set of guidelines to establish how a community will protect and manage its tree resources. The extent of these guidelines is ultimately up to the municipality to determine, but many cities use the standard guidelines recommended by the Arbor Day Foundation to receive Tree City USA status. These guidelines require that an ordinance must establish the following: a tree board or department, a tree care ordinance, a community forestry program with an annual budget of at least $2 per capita, and an Arbor Day Observance and proclamation (Arbor Day Foundation 2006). It is important for a tree ordinance to explain the municipal need for the ordinance, as well as to provide clear definitions that support the purpose of the ordinance (Kerr 2009). Ordinances should firmly establish the duties and authority of the tree board or department. This is especially critical in determining how to handle businesses or individuals who are in violation of the ordinance. The municipal tree board often manages the permitting process for the approved removal of trees on applicable properties.

In addition to providing general protection for trees, tree ordinances may provide extra protection for specially designated trees, such as champion trees or landmark trees. Definitions of these designations should be part of the ordinance to clarify the criteria for designation. For example, the Athens-Clarke County Tree ordinance defines landmark trees as "individual trees, groups of trees, or forested areas that meet one or more criteria for age, size, species, form, character, history, location, or association with an historic event, person, or landmark, and which is officially designated by the landscape management division" (Athens-Clarke County Unified

Government 2013). This particular designation encourages and supports the preservation of large community trees. Other provisions of tree ordinances that may protect historic trees include special permitting for removing trees that exceed certain diameter breast height (dbh) dimensions, presumably protecting larger, older trees. However, many tree protections are encouraged by incentives to protect existing trees or discouraged by punitive measures that municipalities enforce after a tree is damaged or removed. Often these violations are punishable by fines, which for many developers become part of the cost of doing business, and are not real financial deterrents. Most tree ordinances do not have provisions that provide recommendations for tree maintenance or replacement necessitated by climate change.

CHAPTER 5

CASE STUDY: PRINCE AVENUE, ATHENS, GA

To take a closer look at how climate change may impact historic plantings, this study will examine a historic streetscape in Athens, Georgia. This study chronicles the decades-long tradition of planting flowering dogwoods (*Cornus florida*) along Prince Avenue by various citizens and civic organizations. The aesthetic qualities of the Prince Avenue streetscape will be analyzed in terms of their contribution to the character of this streetscape and the sense of place they create along the Prince Avenue corridor. The potential of climactic threats will be considered including drought, disease, pest outbreaks, and changes in phenology. A brief overview of management plans, including the Athens-Clarke County Community Tree Management ordinance, demonstrates the current protections for historic trees. This case study is presented to demonstrate how culturally important landscapes require adaptive management plans to perpetuate their existence in the face of unknown climate futures.

Planting History

Prince Avenue is a major road in Athens, Georgia. It begins at the northwest corner of downtown Athens as a continuation of West Dougherty Street and runs roughly east-west until it reaches the Athens Perimeter loop, where it becomes Jefferson Road. For the purposes of this study, the historic dogwood streetscape is a 1.15-mile stretch of right-of-way on both the north and south sides of Prince Avenue bounded by Pulaski Street to the east and Georgia Avenue to the west. Athens-Clarke County Unified Government manages the right-of-way along Prince

Avenue from Pulaski Street to Milledge Avenue. The Georgia Department of Transportation manages the right-of-way along Prince Avenue from Milledge Avenue west. The width of the right-of-way varies along its length and is intersected by numerous driveways and streets. With the exception of driveways and road intersections, the majority of the right-of-way is vegetated with a ground cover of grass and a low canopy cover of mainly flowering dogwood trees. As of 2008, over 180 flowering dogwoods grow in this area (Figure 5.1). The trees are various ages and sizes, and health and maintenance conditions vary.

The flowering dogwood is widely planted throughout the southeastern U.S. as an ornamental tree, although not typically as an urban street tree. Growing best in partial shade, it is a small understory tree native to the eastern United States. The aesthetic qualities of the flowering dogwood persist through every season, making this tree a popular choice for ornamental plantings. During the springtime, the tree produces a show of white petal-like bracts often mistaken for the actual flower. This display showy display of white appears before the foliage and is commonly referred to as a "harbinger of spring" (Pettis 2007). During the summer, specimens in open sunlight, such as the ones on Prince, develop an umbrella-like canopy of foliage. During the fall, foliage turns red and clusters of bright red berries appear. In winter, some berries may be persistent, and the dark gray blocky bark provides an interesting visual texture to the landscape.

The streetscape of flowering dogwoods along Prince Avenue has a rich history based in community commitment to continuing an established aesthetic along this corridor. As early as the late 1940s, concerned citizens, along with the local City Beautification Committee, an organization started by Mayor Jack Wells, began planting flowering dogwoods as a way to add beauty to the streetscape. During the 1950s, the Athens Garden Club Council planted additional

Figure 5.1: Prince Avenue area used as case study for recommendations for historic trees under climate change conditions.

dogwoods as far down Prince Avenue to the Normaltown area, continuing this tradition. The Ladies Garden Club of Athens sponsored a planting of 35 additional trees by Boy Scout Troop 22 to revitalize the streetscape in 1974. In 1985, with the support of Athens Regional Medical Center (ARMC), a prominent hospital facility on Prince Avenue, and other Prince Avenue business owners, approximately 40 flowering dogwoods were added to the streetscape.[1] The Athens Area Association of Realtors along with Keep Athens-Clarke County Beautiful sponsored and organized the planting of 30 flowering dogwoods in 2000 along Prince Avenue and Dougherty Street (Athens Banner Herald 2000). In 2008, a community group made up of Boy Scouts, neighborhood residents, and the Athens-Clarke County Community Tree Council participated in a project known as Planting Prince, which involved the planting of approximately 25 flowering dogwoods between Pulaski Street and Milledge Avenue (Athens Banner Herald 2008). Athens-Clarke County has designated the majority of the flowering dogwoods in the right-of-way along Prince Avenue as landmark trees due to their age and/or the historic nature of the plantings. Although not part of the designated study area, another significant specimen dogwood planted on ARMC property in 1951 has received landmark tree designation due to its size and age. The beauty and history of this tree inspired ARMC to incorporate the flowering dogwood as part of its new logo in the 1980s (Athens Banner Herald 2008).

The Prince Avenue corridor encompasses a wide variety of residential and commercial neighborhoods. Two National Register of Historic Places (NRHP) historic districts border the study area along Prince Avenue: Boulevard Historic District and Cobbham Historic District, with several others in close proximity. Several NRHP properties have Prince Avenue addresses and other properties could qualify for nominations (Athens-Clarke County Unified Government

[1] Historical planting information taken from a promotional pamphlet "The History of Dogwoods and Prince Avenue" published by Planting Prince in 2007, a collaborative community effort to continue the Prince Avenue dogwood tradition.

2012). As the character of these developments varies along the corridor, so does the aesthetic of the different time periods represented. The one unifying feature of this street is the consistent right-of-way planting of flowering dogwoods (Figure 5.2). As the above history demonstrates, local residents and businesses value the beauty added to the street by these trees, particularly during the spring and fall. During periods of decline of individual dogwoods, various community groups have organized revitalizations to continue the tradition of making Prince Avenue a distinct, recognizable corridor in Athens. The small stature of the trees gives an open aesthetic to the street, allowing for individual properties to be observable during all seasons. This allée of flowering dogwoods not only defines the corridor itself, but also creates a continuous setting for the diverse properties along the avenue.

By most accounts, the decision to plant dogwoods in the right-of-way on Prince Avenue was based on aesthetics, as this species is a poor choice for the stresses of urban conditions and provides minimal shade as a street tree. Although some areas of the right-of-way are too narrow to support larger canopy trees, several stretches could easily accommodate much larger trees that would provide more environmental benefits to the corridor.

Potential Climactic Threats

The flowering dogwood is susceptible to several diseases such as dogwood anthracnose (*Discula destructive*) and powdery mildew (*Erysiphe pulchra*). Dogwood anthracnose is most prevalent in natural habitats, particularly in the Appalachian Mountains (Holzmueller et al. 2006). This fungal disease is thought to have been brought over on Oriental dogwoods (*Cornus kousa*) from Asia as early as the 1970s. Dogwood anthracnose thrives in areas where conditions are continually moist. Symptoms of the disease include lower branch dieback and black leaf

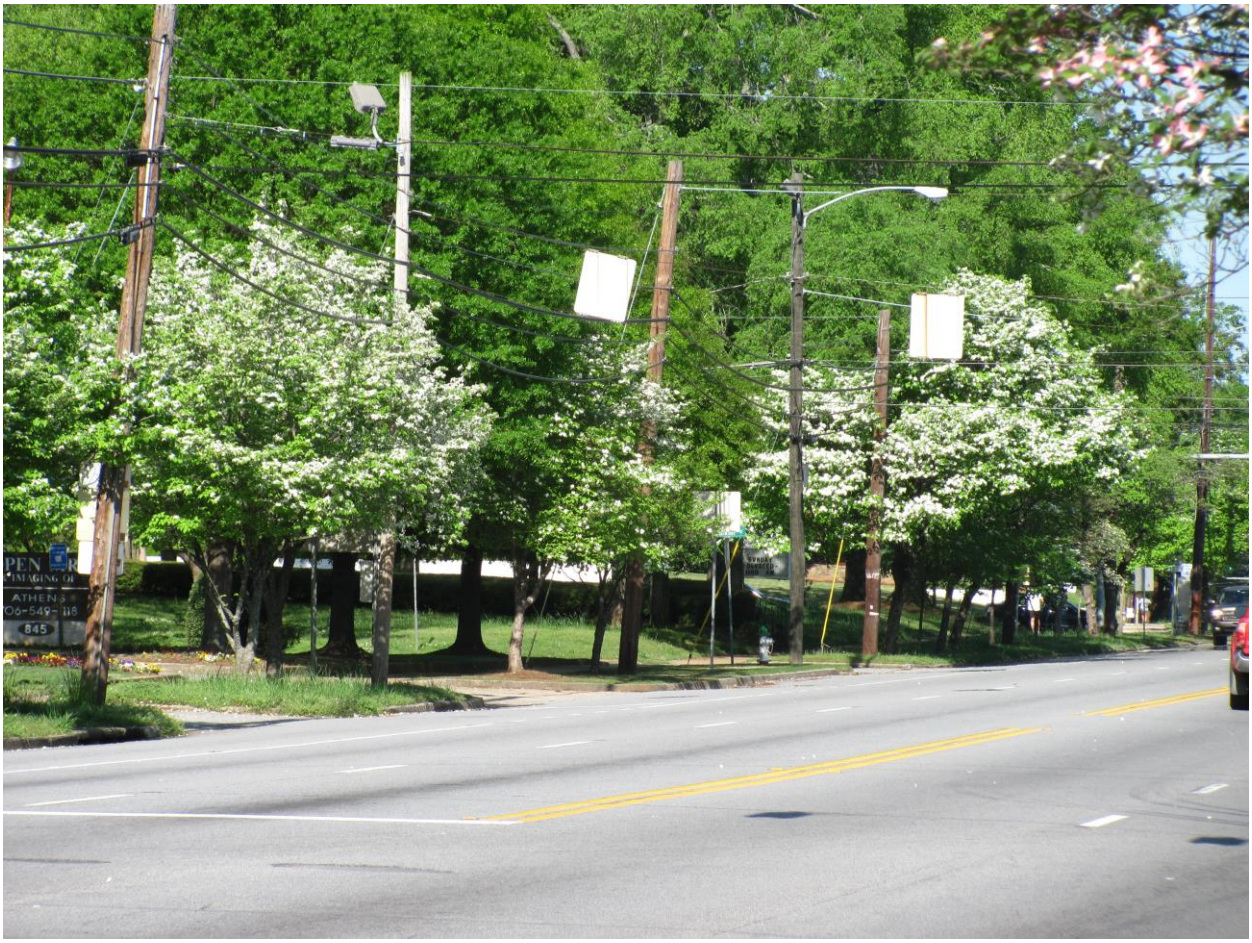
Figure 5.2: Prince Avenue dogwoods during spring bloom time

spots. Although there is no viable treatment for large outbreaks of dogwood anthracnose, individual trees can be treated with fungicides and by pruning diseased branches. As the fungus thrives in moist areas, it has not been problematic in the urban setting along Prince Avenue. Some new cultivars, along with *Cornus kousa* varieties, are resistant to the disease and may be options in areas where outbreaks are prevalent. Powdery mildew is a common disease in flowering dogwoods in planted landscapes, as it does not require excessive moisture to thrive. This fungal disease appears as white powder on leaves. Although it decreases the overall health of the tree, this disease is not typically fatal and can be managed with the use of fungicides and proper pruning. Disease resistant cultivars for powdery mildew are also widely available in

nurseries. Overall, these two diseases are not particularly threatening to the Prince Avenue dogwoods under existing environmental conditions. Although neither of these diseases is directly attributed to climate change, they can be particularly hazardous to specimens from other climate change stressors. Climate change factors, such as changes in temperature and moisture, may also increase the prevalence of these and other diseases.

The most recent threat to the Prince Avenue dogwoods, and a potential recurring threat, has been extended periods of drought. Due to their shallow root system, flowering dogwoods require moist, well-drained soil conditions. Urban plantings, especially ones in open sunlight like the Prince Avenue trees, require supplementary watering in periods of low rainfall. In 2008, the new plantings along Prince Avenue suffered a significant decline that was attributed to compacted soil conditions and insufficient rainfall.[2] Drought has affected many tree specimens throughout the U.S. southeast in recent decades. According to Dexter Adams, the University of Georgia campus in Athens has experienced an unprecedented decline and loss of trees over the past five years to due drought and insect infestations.[3] Because climate forecasting for the southeast U.S. is currently unpredictable especially with regard to precipitation, land managers will need to monitor water needs regularly to maintain the health of the Prince Avenue dogwoods. At some point, if drought periods persist and city water use is restricted, land managers will need to evaluate the feasibility and public support for maintaining these historic plantings.

Although the flowering dogwood is unlikely to be driven out of the Athens, GA area due to projected increases in temperature under typical site conditions (the species is recommended

[2] From conversation with Andrew Saunders, Athens-Clarke County Community Forestry Coordinator, October 3, 2012.
[3] From conversation with Dexter Adams, the Director of Facility Management for the UGA Grounds Department, on September 27, 2012.

for planting in hardiness zones 4-9), changes in temperature have the potential to alter the plants' phenology. One of the most aesthetically visible changes in phenology would be the acceleration of spring onset. With cold season temperatures increasing, and fewer days of frost, the bloom time of the flowering dogwood could come earlier in future years. The association of the flowering dogwood with its traditional bloom times in the southeast from mid-March to mid-April would be altered. Many celebrations associated with the onset of spring, such as dogwood festivals, would have to be held earlier to be in concert with actual bloom times. For example, the Atlanta Dogwood Festival is currently held the 3rd weekend of April annually, which is very close to the end of current bloom time. Phenological changes may potentially alter plant species interactions with pollinators, beneficial microclimate organisms such as mycorrhizae, and pests. These potential outcomes could result in diminished or non-existent spring blooms, diminished color brilliance during fall senescence, and diminished abundance of winter berries. These changes can have unknown implications for perceptions of sense of place if plant aesthetics are subtly or substantially altered (Hunter 2008).

Protection for Prince Avenue Dogwoods

The flowering dogwoods on Prince Avenue are currently designated by the Athens-Clarke County Community Forester as *landmark trees*. The Community Tree Management Ordinance gives *landmark trees* the same protections as *protected trees* as created by the ordinance. The following definitions from the ordinance provide clarity for these special distinctions:

> *Landmark trees*: "individual trees, groups of trees, or forested areas that meet one or more criteria for age, size, species, form, character, history, location, or association with

an historic event, person, or landmark, and which is officially designated by the landscape management division"

Protected trees: Trees planted or conserved to meet the requirements of this chapter, Athens-Clarke County trees, designated landmark trees, and trees within a designated Tree Preservation Area (Athens-Clarke County Unified Government 2013).

The ordinance clearly outlines the requirements for the proper maintenance of these trees. The tree ordinance mandates that these trees should be actively protected during construction or other property disturbance activities, and passively protected during their existence through specifically outlined care and maintenance. For landmark trees that die or have been legally removed, property owners are required to replace the specimen with a tree of the same species or of a species with a similar canopy size. In March of 2013, Athens-Clarke County replanted a small section of Prince Avenue between Pulaski Street and Milledge Avenue under the specifications of this requirement. This planting included 12 flowering dogwoods plus 14 other trees of mostly small to medium sized tree species.

Special permitting from the landscape management division administrator is required to remove landmark and protected trees from properties. Because the Prince Avenue dogwoods are located in the public right-of-way, it is unlikely that they are at risk of unauthorized removal by private individuals or businesses. Individuals found in violation of the tree ordinance requirements during construction or property maintenance will be issued a stop work order or a certificate of occupancy may be withheld, if relevant. If a tree is removed without proper authorization, the individual responsible for the damage will be penalized upon conviction. Penalties for city ordinance violations include a fine of up to $1000 and/or imprisonment not exceeding six months, as indicated by the Athens-Clarke County municipal code. The Georgia

Department of Transportation mandates individuals responsible for illegally removing trees from the State managed right-of-way are subject to fines from $10,000 to $20,000 per offense and must pay restitution for damaged property as outlined in the Georgia Department of Transportation Landscape Manual. This penalty could be applied to any trees damaged along Prince Avenue from Milledge Avenue west.

Nomination to the NRHP or the local historic register would provide additional recognition to the Prince Avenue dogwoods. As part of this designation process, completing a cultural landscape report (CLR) would be beneficial to assist in the inventory and management of this important cultural resource. A CLR would provide a clear, concise history of the all of the plantings and period maps representing the various planting efforts. Past and current inventory maps will become critical to document this landscape particularly if it does become threatened due to climate change. The treatment and recommendations chapter of the CLR could provide more specific management options for replacing failed or failing plantings. This treatment plan could outline how trees will be assessed for potential climate-induced stressors, and what actions could be taken to preserve them without significantly altering the aesthetic nature of the plantings.

The NRHP designation or local designation as a historic district would be an appropriate classification of this linear group of historic plantings. Establishing this area as a district would be an additional way to ensure that new development along Prince Avenue maintains the current aesthetic of the right-of-way areas. The significance of this district to the NRHP must be established based on one of the four following National Register criteria:

1) The property is associated with events that have made a significant contribution to the broad patterns of American history.

2) The property is associated with the life of a significant person in the American past.
3) The property embodies distinctive features of a type, period, method of construction, or high artistic values, or represents a significant and distinguishable entity whose components may lack individual distinction.
4) The property and its site yield, or are likely to yield, important information in history or prehistory (Tyler 2000).

The event (1) definition most accurately describes why this landscape is worthy of nomination. This "event" could be defined as the continued tradition of planting the Prince Avenue right-of-way with flowering dogwoods by various individuals, businesses, civic organizations, and government agencies since the 1950s as a way to revitalize an emerging mixed-use corridor in an urban area. This gives credit to the district as a historic vernacular landscape. Preservation Brief 36 defines this type of landscape as "a landscape that evolved through use by the people whose activities or occupancy shaped that landscape. Through social or cultural attitudes of an individual, family or a community, the landscape reflects the physical, biological , and cultural character of those everyday lives" (Birnbaum 1994). The aspects of historic integrity that have been maintained throughout the evolution of this landscape are location (Prince Avenue right-of-way), materials (flowering dogwoods), and feeling (light, open canopy, and spatial relationship of the right-of-way to adjacent properties).

As this landscape has evolved with the continual development of Prince Avenue, and will continue to evolve, special consideration should be given to the four treatment options previously outlined in Chapter 4. To allow this historic landscape to function as it has historically, rehabilitation would be a desirable choice for treatment as it is the most flexible

of the treatment options. Under current conditions, this allows modification of the right-of-way in regards to the needed addition or reconfiguration of infrastructure, such as utilities and vehicular pullouts. Under climate change scenarios, this treatment option would allow for adaptive experimentation in regards to managing a potentially stressed urban tree population. General recommendations for preservation or replacement strategies for historic landscape vegetation, as well as specific recommendations for Prince Avenue, are explored in the following chapter.

CHAPTER 6

RECOMMENDATIONS

Preparing for unknown climate futures is a complex process. The potential effects of climate change on our natural and built environments are minimally predictable. This presents unique challenges for land managers of historic landscapes. What tools are available for them to prepare for our changing environment? How can they make decisions that are wise for both protecting historic resources and responsibly managing environmental resources? This chapter explores general recommendations for managing historic trees. As these recommendations are general, land managers are encouraged to explore further solutions that will directly address the range of issues that they may have to face in their own unique landscapes. The basic tools for preservation planning apply to all historic landscapes, including landscapes vulnerable to climate change. In addition to categories included in cultural landscape reports (CLR) which includes historic research, inventory and documentation, site analysis, treatment plans, and record of treatment (Birnbaum 1994), land managers should include or incorporate climate assessments, species monitoring, and alternative treatment strategies for threatened species. These tools provide a framework for decision-making should this become necessary. Often, land managers have already gathered much of this needed information, and may only need to update management plans to make sure that they include appropriate climate-related categories. This information can be assembled as part of an actual CLR, especially if the resource is nominated to the NRHP or is given a state or local designation. For properties not designated by national or

local preservation processes, this preservation management plan can be included as part of local tree ordinances.

Historic Research, Inventory, and Documentation

The first and perhaps most important step in decision-making for historic landscapes is conducting historical research. This process will not only help identify historic resources, but will allow for qualifying the significance of these features. Thorough research will give support to any initiative to maintain historic landscapes by demonstrating the overall importance and value placed on them by stakeholders, past and present. Research should include past period plans if the current landscape has incurred changes since their implementation. These plans can be difficult to reconstruct without photographic or descriptive accounts, as past vegetation leaves little evidence behind. In addition, any available oral accounts of site history should be recorded. Researchers should compose all collected information into a narrative describing the evolution of the landscape up until present times.

Land managers should conduct a current inventory of historic landscapes to establish the boundaries of the historic landscape, to show the spatial layout of the landscape, and to identify all present resources, historic and non-historic. The National Park Service has published several National Register Bulletins to assist in the development and use of proper techniques in performing historic landscape inventories, including guidance for several specific landscape types (Birnbaum 1994). The expertise of a certified arborist should be incorporated with this inventory to verify the age of historic plantings and to assess the overall current health conditions of individual historic trees. An arborist will be able to identify any structural or other health problems that may require special consideration in the treatment plan, such as additional

monitoring. Inventories become especially important to record site history for future generations in the event that present conditions change.

Site Analysis

Once all of the available research and inventory information has been collected, land managers and preservation experts can perform a site analysis informed by the historic significance and integrity of location, design, setting, materials, workmanship, feeling, and association of the site. Assessing the significance of historic landscapes will assist land managers in determining how intensive efforts to maintain them should be. For instance, if there is no evidence to support high integrity of these landscapes, then the potential changes caused by climate change will not be particularly detrimental to the already altered historic fabric of the site. As part of the analysis of the integrity of the landscape, specific information about each historic tree should be provided to determine its overall importance and contributions to the function and aesthetic of the landscape. Either as part of this portion of the assessment, or as a separate section, a list of characteristics of each tree species on site should be compiled to use as a tool in following sections. This list should contain at least three category types of information: aesthetic characteristics, ecological characteristics, and plasticity characteristics. Aesthetic characteristic include canopy size category, mature crown form, fall leaf color, and flower color. Ecological characteristics include growth rate, native status, wildlife value, average life span, soil moisture and pH requirements, and light requirements. Plasticity characteristics include precipitation and moisture requirements, drought tolerance, known pest issues, plant hardiness zone (Hunter 2011), and a future suitability ranking based on overall plasticity (Leskiw 2009). The importance of tree plasticity (the ability of a species to perform well over a range of

environmental conditions), cannot be overrated, as the overall endurance of trees is their most important contribution site ecology (Hunter 2011). Most historic trees are designated as such due to their age, which helps to create continuous stable habitat conditions for plant communities (Arnold 1993). Replacement trees without the plasticity to survive a range of conditions will require future replacements, which is less economical in the long term.

Treatment plan

The development of a treatment plan is an opportunity to formulate an agreed upon vision for maintaining the significance of historic landscapes. A plan is necessary to set preservation goals and to ensure that the proper tools are available to achieve these goals. Cultural landscape reports include a treatment chapter that outlines and justifies the logic behind treatment goals for historic landscapes. Given the potential for climate related impacts on these landscapes, however, a range of considerations based on Melnick's proposed solutions (see Chapter 3) for managing cultural landscapes should be explored and related back to the preservation goals established. Any special notes about the significance and function of individual plants within the landscape need consideration in the recommendation process. For example, if the main historic goal of live oak street tree plantings in Savannah, GA, is to provide a shade canopy for local streets to mitigate the effects of summer heat, any recommended treatment strategies or replacement species should reflect this goal by providing a similar or improved function. If the historic goal of planting the live oaks was to provide abundant acorns for urban fauna, then another appropriate oak species could be considered to achieve this intended function if a replacement tree becomes necessary. Even in instances where preservation or restoration is the recommended treatment, land managers and preservationists need flexible options for replacing

vegetation. This will provide alternative solutions if extinction, extirpation, or unfeasible maintenance requirements become realities of climate change.

A variety of strategies for treatment options can be employed for uncertain situations. After a climate assessment for the area has been performed, a range of tools should be developed for dealing with climate change scenarios. These tools for maintaining the function of historic vegetation include, but are not limited to, specialized planters, an integrated pest management (IPM) program, fungicide applications, cost/benefit analyses, species replacement lists, and the potential loss of plantings. Specialized planters such as tree wells and Silva Cells may favorably alter the microclimate of tree installations by controlling moisture and mitigating soil compaction that can make plants more vulnerable to climate-induced stressors (Figure 6.1). Treatments like these may be suitable if specimens can be replaced in-kind with predictably favorable results, given fewer stressors. Land managers can use the tree species characteristic list outlined above to recommend appropriate replacement species for specimens that are no longer realistic to replace in-kind. IPM practices can help to determine if specific fungicide and pesticide applications are necessary options for small-scale plantings where pest and disease outbreaks can be affordably controlled, or if less chemically intensive measures can be applied. However, for large-scale plantings, such as natural forested areas, these applications are often too expensive or too labor intensive to manage effectively. Land managers need to perform any relevant cost/benefit analyses for maintaining plantings or for maintaining in-kind replacements. Research indicates that efforts to maintain current or past environmental conditions require greater energy inputs (Millar et al. 2007), and could become quite costly to manage. For example, in the southern U.S., trees with a high water requirement will likely suffer under prolonged drought conditions in the

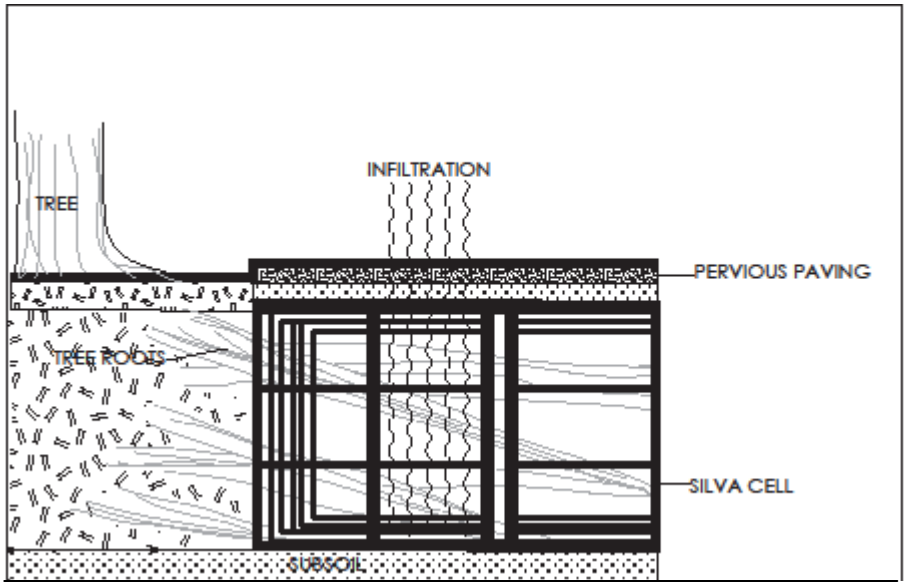

Figure 6.1: Silva cells alleviate soil compaction, and when used with pervious paving, allow for infiltration of rainwater to tree roots.

future. Can maintenance budgets support the expense of the routine watering schedule that may be required to keep these trees healthy? At what point does this become infeasible to continue? These questions are answerable only if land managers establish preservation goals. For plantings that serve a specific aesthetic, social, or ecological purpose, a similar species that continues to perform well in the area can be compared for achieving preservation goals. If there is a species that provides a function similar to the original, this can be considered as a viable replacement. If several species would achieve a similar function, replacement species can be prioritized by their plasticity and/or improved function in the landscape. If plantings are properly evaluated and all of the above options have been considered and rejected, land managers will have to face the reality of losing historic resources. If future cultivars are developed that can withstand new climate conditions, restoration or rehabilitation of these landscapes may be feasible as long as these historic resources were documented properly. For example, if a disease or pest outbreak decimates the allée of sycamore trees at the Biltmore Estate in Asheville, NC, this historic

feature may be lost. Proper documentation of the allée can guide land managers in accurately reinstalling this feature if a resistant cultivar is developed. Some lost landscapes may just become part of the dynamic history of human impact on the land, preserved only in photos and written accounts for future generations.

Climate Assessments

Climate assessments are an important, but not necessarily critical, tool for historic landscape management. As most landscape managers do not necessarily have time to continually seek peer-reviewed literature that relates to their locale (Hansen and Hoffman 2010), climate assessments can be based on widely available resources. The USDA plant hardiness zone map is one of these important universally available tools (Hunter 2011). As this map is updated, an established species characteristic list can be consulted to determine the continued appropriateness of a species for a geographic area. Local county extension offices or other local resources may be able to provide additional local information concerning precipitation, temperature trends, and disease outbreaks. The importance of performing any type of climate assessment is to determine the range of potential climate futures for the local or regional area. Because these futures are not entirely certain, one of the most important goals of understanding or performing climate modeling is to accept that a range of futures is possible for their landscapes. The rate of change caused by anthropogenic variables is not certain, as global human behaviors continue to change at unpredictable rates. Observing changes in climate conditions and tree health is the best means to support any management decisions.

Species Monitoring

One of the most effective methods for managing historic plantings is performing species monitoring. The development of a system and timeline for monitoring is a crucial part of routine resource maintenance. Not only are individual specimen evaluations necessary, analyses of these individual evaluations to look for species-wide health trends are valuable. If certain species are performing poorly, any observed reasons for this performance should be documented (See Appendix A). This documentation will help to clarify when alternative strategies for tree maintenance become necessary. Because some pest and disease outbreaks can decimate species in a short amount of time, some type of recorded monitoring should be performed on a quarterly basis. Early detection of "pioneer populations" of pests is essential to preventing widespread outbreaks that can devastate urban tree populations (Tubby and Webber 2010). Any changes in phenology such as bloom times or senescence should be noted as well, as they may indicate sensitivity to temperature changes and relate to broader ecosystem relationships such as pollinator life cycles.

Alternative Treatment Strategies

Alternative treatment strategies, such as replacement species and specialized planters, have already been largely discussed as a part of overall treatment plans. As previously stated, any proposed alternative treatment strategies should support overall site historic preservation goals. If strategies cannot be developed to support current goals, then perhaps the goals need to be revisited by stakeholders. As with species monitoring, land managers need continually to evaluate alternative treatment strategies for their feasibility. As climate conditions continue to evolve, historic landscapes will need to adapt continually to maintain their historic importance.

Strategies currently considered viable options for managing historic trees may become irrelevant as conditions change.

One tool that may provide meaningful results for historic landscape replacement vegetation is the use of landscape visualization. This process involves showing stakeholders images of alternate climate change and management scenarios of local landscapes to motivate involved individuals and groups into action (Sheppard 2005). In one study, Canadian stakeholders were shown visualizations of modeled climate change scenarios as seen from space. Participants reported that these images influenced their visions of the future and shaping current policy (Sheppard 2005). Human responses to visual imagery have been proven to influence decision-making by increasing cognition, shaping emotional responses, and influencing behaviors. This tool could be used to help stakeholders decide on aesthetically compatible management decisions for historic landscapes. Although the overall ethical standard and effectiveness of landscape visualization in promoting appropriate stakeholder responsiveness to climate change is still under evaluation, its effectiveness in providing visualizations of different treatment strategies for historic landscapes would be similar to showing different potential landscape plans to potential clients.

Specific Recommendations for Prince Avenue

The Prince Avenue flowering dogwoods are an important local historic resource for the Athens area, and as a case study can be a model for similar situations elsewhere. Their designation as local *landmark trees* provides them with a certain level of protection from unauthorized removal and establishes clear maintenance requirements. The city has performed a current, thorough inventory documenting the present conditions of each individual tree.

However, documentation of past conditions and setting preservation goals seems incomplete. A CLR, or at minimum a general management plan, would be an appropriate and cohesive way to synthesize all available information about this resource and to identify where gaps in information exist.

Nomination to the National Register of Historic Places or local historic register as a historic district would give additional recognition to this resource. Because the right-of-way is managed by Athens-Clarke County and the Georgia Department of Transportation, NRHP designation or local designations would provide minimal extra benefit to this resource in terms of protecting trees from unauthorized removal. Designation as a historic district would be most beneficial in shaping future developments along the corridor. Nomination would also establish a type of significance, period of significance, and level of integrity of the site. These classifications would assist in the establishment of overall preservation goals for this resource.

Setting preservation goals is the most important factor in the preservation of the Prince Avenue dogwoods. Using the basic tools of preservation planning based on the CLR, and the additional recommended tools for adapting historic landscapes to climate change, will aid in the perpetuation of this landscape for future generations. Once goals are set, land managers and stakeholders can weigh treatment options, including additional treatment options for climate change scenarios. Assuming that rehabilitation is the most appropriate option for this dynamic corridor, compiling acceptable options for future scenarios is more flexible.

Potential suggestions for managing the Prince Avenue dogwoods as a historic landscape include methods to maintain the existing or in-kind plantings, as well as alternate species substitutions for failed or failing plantings.

Watering program – If drought conditions worsen in the Athens area, the city could establish a regular watering program to satisfy the precipitation requirements of these trees. This could prove to be a costly endeavor in terms of labor and resource requirements, considering the number of existing plantings, and could be publicly unpopular if city-wide watering restrictions are placed on private and public water use.

Cistern installation and irrigation – The installation of a cistern and irrigation system along Prince Avenue where infrastructure allows would offset the needs of city water for watering during drought conditions. However, if drought conditions fluctuate or diminish, the investment in this extra infrastructure would be an impractical use of city resources.

IPM/Pesticide/fungicide applications – In the event that pest and other disease outbreaks among these flowering dogwoods prove to be detrimental to this historic landscape, IPM strategies may be used to control further outbreaks. Depending on the appropriate strategy, this could prove costly and/or labor intensive.

Companion shade planting – One of the criticisms of using dogwoods as the primary street tree along Prince Avenue is small canopy size and typical poor urban performance. Implementing companion shade plantings of larger canopy trees on the other side of the sidewalk from the right-of-way is a potential solution to this problem. These larger canopy trees would provide adequate shade for the corridor, as well as reduce stress on the dogwoods caused by their current position in open sunlight. The current right-of-way aesthetic provided by the dogwoods would not be diminished by these additional plantings. This plan requires continuing community educational programs to encourage private property owners to install or allow the installation of these larger canopy trees.

Given the amount of time it would take these trees to become large enough to provide beneficial shade, this is a long-term solution. Any sections of the right-of-way currently shaded by larger canopy trees could be studied to see if the dogwoods in these areas perform better.

Tree wells/Silva cells/specialized planters – In areas where soil compaction is a suspected stressor and has caused tree mortality or decline, soil bulk density testing should be performed and the cause of compaction should be evaluated. In areas where high foot traffic is inevitable and will continue to create compacted conditions, specialized planters should be installed when new trees are planted. If compaction was caused by a one-time or non-continuing event, the root zone should be aerated with an air spade to alleviate compaction stress.

Cultivar testing – As several cultivars of dogwoods have been developed to resist various diseases, new varieties can be planted as failed or failing plantings need replacement. Local nurseries can provide information on new cultivar selection, in terms of disease resistance and hardiness factors. During the species monitoring process, these varieties can be analyzed for performance in this urban environment.

Alternate species testing – Because Athens-Clarke County owns a variety of urban properties, tree species on these properties provide opportunities for monitoring performance under future climate change conditions. The recent plantings along Prince Avenue of black gums, golden rain trees, Kentucky coffeetrees, trident maples, and red maples can be monitored for performance, aesthetics, and general public acceptance. Athens-Clarke County has already developed an extensive Tree Species List that includes physical characteristics, environmental characteristics, and recommended uses for tree

species. Considering the intent of the original dogwoods plantings, this list should be used to compare the function, feasibility, and aesthetics of potential alternate plantings. Additional information that would be beneficial for updating this list for changing climate futures would be precipitation and moisture requirements, known pest issues, seasonal ecosystem services or relationships, plant hardiness zone, and a future suitability ranking based on overall plasticity.

Potential replacement species- Based on the aesthetic function of the flowering dogwoods along Prince Avenue, a sample of potential species substitutes is provided (Table 6.1). This substitute table serves as an example of informed decision-making processes based on the historic function of this resource.

Table 6.1: Potential replacement species for the flowering dogwoods along Prince Avenue.

Species	**Similarities to historic species/ advantages**	**Differences/limitations**
Downy serviceberry	white flowers present in spring, small canopy size, medium leaf texture, recommended for intended planting area, hardiness zones 4-9, moderately drought tolerant, native tree	orange fall color, does not improve current shade conditions
Eastern redbud (white)	white flowers present in spring, similar canopy size and form, medium leaf texture, recommended for intended planting area, moderately drought tolerant	yellow fall color, not recommended for full sun, hardiness zones 4-8
Crapemyrtle	white flowers, red fall leaf color, urban tolerant, full sun, hardiness zones 6-9, high drought tolerance	summer flowers, multi-trunk form, very small canopy, fine leaf texture
Fringetree	white flowers present in spring, native tree	yellow fall color, small oval-form canopy, not drought tolerant, not recommended for full sun

Conclusion

The maintenance of historic trees is especially important given their vital role in site ecology and creation of sense of place. Current examples of tree devastations including the American chestnut, eastern hemlocks, and green ash may be foreshadowing for future loss of other beloved trees due to changes in climate. Land managers of historic landscapes need to consider climate change as an important variable that influences the maintenance of historic properties. Incorporating information related to unpredictable future conditions can assist land managers in planning for the preservation of important landscapes. Developing adaptive strategies now that support preservation goals are key to future decision making.

To provide adequate protection for historic trees, land managers need to provide clear directives for the maintenance and management of these resources. First, these resources must be identified and designated as needing specific treatment. If a local tree ordinance or preservation ordinance is already in place, these documents can be amended to reflect preservation and treatment plans for historic trees. Including climate assessments, species monitoring, and alternative treatment plans as part of the management framework established by the CLR process will enable land managers to care properly for historic trees under future climate conditions. The documentation of these processes and management decisions can be studied to determine the effectiveness of treatment plans, and can help other land managers understand outcomes for the range of alternative treatment strategies in historic landscapes. Additional research on the effects of climate change on trees in the built environment, the impacts of historic tree loss on sense of place, and cost/benefit analyses of maintaining historic trees impacted by climate change would be beneficial to land managers responsible for historic trees. As new research becomes available, it can be incorporated to inform decision-making using the processes outlined by this chapter.

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APPENDIX A

SAMPLE TREE MAINTENANCE CHART

Date: 7/1/13 Pg: 1
High Temp: 89

Specimen # (FID)	Species	DBH	Root Struct	Root Hlth	Trunk Struct	Trunk Hlth	Scaff Hlth	Leaves	Failure Pot	Target	Maint Prior1	Note1
ACC_001	Cornus florida	6.5"	1	2	3	1	3	3	high	y	pruning	crown dieback
ACC_002	Quercus nigra	20"	1	1	1	1	2	1	low	n	mulch	
ACC_003	Fraxinus penn.	8"	1	1	2	3	2	3	high	y	removal	EAB

Specimen # (FID)	Maint Prior2	Note2	Pests	Disease	Blooms pres	Sen. pres	Comments
ACC_001	fungicide	leaf spot	n	13	n	n	13 improving
ACC_002	NA		n	0	n	n	
ACC_003		crwn dieback	9		n	n	infested area

Pg: 2

* unquantified numbers in data columns indicate ratings to be defined by user. For example, a root structure rating of 3 could be defined as "poor condition, girdling roots"