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CHANGES IN THE URBAN FOREST IN
GRAND JUNCTION, CO, 1980-2004.

presented by

Heidi Marie Frei

has been accepted towards fulfillment
of the requirements for the

M.S. degree in Forestry

J. James Kielbaso
Major Professor's Signature

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Date

CHANGES IN THE URBAN FOREST IN GRAND JUNCTION, CO, 1980-2004.

By

Heidi Marie Frei

A THESIS

Submitted to
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ABSTRACT

CHANGES IN THE URBAN FOREST IN
GRAND JUNCTION, CO, 1980-2004.

By

Heidi Marie Frei

Urban forest characteristics, tree size, condition, and species diversity for trees publicly and privately owned within neighborhoods defined by age, were studied in ten cities nationwide in 1980. Grand Junction, Colorado, included in the 1980 sample, was again sampled in 2004 for a comparative analysis that also included a survey of public perception. Species diversity on public property was far below that on private property and has decreased considerable during the intervening period. In older neighborhoods, the influence of ownership had little effect on overall species diversity. Diversity in the oldest neighborhoods was higher than that found in younger neighborhoods. Trees found on private property were also in better condition and represented by higher percentages of saplings than those on public property, although this percentage has decreased significantly over time. Condition rating and neighborhood age appear to be inversely related, a trend that remained unchanged over 24 years. Size appeared to increase incrementally with age of neighborhood. More large and medium size trees were found on public property. This has remained unchanged during the sample period, due to a reduction in tree planting on public property.

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To my family and Mr. Justin Kunkle for their continuous support and encouragement and in memory of Mr. Michael J. Frei.

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I'd like to thank my mother, Mary Margaret Jimenez Frei, for her strength and support. To my brothers, Eric, Roland, and Kurt, and my sisters, Ingrid, Krystal, and Jennifer, for their love and friendship. Special thanks to my sister, Cheryl, for her assistance in data collection. To Mr. Justin Kunkle for his enduring encouragement and advice and the Silveira family for their love and guidance.

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INTRODUCTION

As communities become increasingly urban and suburban, it is important to realize and quantify the several values of the urban forest. An estimated 80% of the United States population can be associated with urban or larger metropolitan areas (Nowak et al. 2001, US Census Bureau 2000). A growing majority of those associated with a larger metropolitan area reside in communities in close proximity to urban centers that offer a more pastoral or natural setting often absent from urban areas (Van Wassenaer et al. 2000). The lure of outlying communities within a reasonable commute, via a modern network of roadways, continuously drives peri-urban land development. Rapid population growth followed by the consumption of land has a substantial effect on the urban forest (Profus 1992), defined by Miller (1997) as the sum of woody vegetation in and around any human settlement. Due to the sprawling pattern of modern development, urban and community forestry is becoming increasingly important to improve overall quality of urban life and to promote urban residency, relaxing pressure on lands valued for agriculture and recreation (Nowak et. al 2001; Gatrell and Jensen 2003).

Though the benefits of urban trees are widely recognized, continuous development threatens the ability of urban forests to actualize these benefits (Dwyer et. al 1992).

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While trees and other vegetation in urban areas have a great potential to grow and survive, they are constantly subjected to the changing designs of humans and their omnipresent urge to develop and expand. Species selection, planting and care are highly influenced by a large number of private landowners in metropolitan areas. Likewise, professionals are charged with the care and management of urban vegetation on public lands (Miller 1988, Harris 1992). And, unlike natural forest environments, the urban environment has the potential to experience rapid changes that can influence urban forest sustainability (Nowak 1993). Vegetation in the urban environment is highly influenced by urban development history and management regimes that have occurred throughout time (McBride and Jacobs 1976, 1986; Dwyer et al. 2000). Consequently, land use and development history create varying quantifiable patterns of urban forest characteristics distributed piecemeal throughout the city.

Characteristics of urban trees reflects various human activities and habitats and, though varied on a citywide level, may be homogeneous on the smaller neighborhood level (Grey and Deneke 1986, Miller 1997). Variations in development history and zoning patterns throughout a city create a jumble of land use and spatial distributions not equally amenable to tree growth (Nowak et al. 1996). Planting, management, and an understanding of natural systems is helpful to mitigating any possible negative implications of human development (Clark 1997). Additionally, incorporating the values of urban constituents while educating the population on the benefits reaped through urban forest management should be integral to the field. However, these o

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opinions and attitudes are rarely considered in regard to urban and community forestry management decisions (Kielbaso 1982).

The urban forest has been defined by Clark et al (1997) and Clark and Matheny (1998) as *"the naturally occurring and planted trees in cities which are managed to provide the inhabitants with a continuing level of economic, social, environmental, and ecological benefits today and into the future"*. Sustaining this forest requires attention to all trees in a community regardless of ownership. It also requires a mechanism of relaying this information and involving the public to continually support urban forestry programs. Information from accurate and regular urban tree inventories and public perception and attitudes surveys are also essential to urban and community forest sustainability (Dwyer et al 2001).

This current analysis presents a case study in some aspects of the urban forest history of the community of Grand Junction, Colorado, USA. The objectives of the study were (1) to determine changes in the urban forest between 1980 and 2004, including tree condition/health, species composition, and size, and (2) to determine if trends are influenced by whether trees are a public or privately owned resource, and by age of neighborhood development; and (3) to identify urban residents' attitudes towards street trees.

More specifically, the goals of this study were to:

1. Compare and determine urban forest dynamics in Grand Junction, CO from 1980 to 2004 for the following attributes:
    a. Species composition,
    b. Size of tree, and
    c. Condition/health of tree.
2. Compare the above mentioned characteristics of urban trees between:
    a. Private property and public property, and
    b. Three age classes of neighborhood development, and to identify whether public or private management or age of development influence the urban forest characteristics previously listed.
3. Evaluate attitudes toward urban trees in Grand Junction overall and among three age classes of neighborhood development for:
    a. attitudes regarding both positive and negative attributes of trees,
    b. location preferences for future tree plantings,
    c. willingness to participate in and pay for various volunteer activities and ecological programs,
    d. the maintenance of urban trees, and
    e. the importance of trees in certain locations.

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LITERATURE REVIEW

Urban Tree Benefits: the need to evaluate and improve our forests.

Urban and community forests offer a myriad of values to residents that can be classified as social, economic, environmental, and even spiritual or psychological (Miller 1997). However, in comparison to related disciplines, not enough is known about this valuable resource. Socially, urban forests provide a sense of community and identity. The simple act of planting fosters an attachment to the surroundings and creates a sense of ownership and pride (Driver et al 1980). Those who plant a tree and are amongst trees often feel a spiritual connection or link to nature, not often found in some highly urbanized locations (Dwyer et al 2003).

Based on the theory of defensible space, that is that the physical features of a neighborhood impact the strength of communities and, consequently, rates of crime (Newman 1972), Kuo (2003) analyzed whether trees and urban vegetation in general could influence social ecology. In a comparative analysis of two Chicago housing projects, one containing significant vegetation while the other was devoid of vegetation,

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it was found that outdoor settings with trees are much more preferred and play a significant role in inviting residents outside (Kuo 2003). It was found to have higher use rates of green outdoor spaces by both adults and children and more informal contact among neighbors (Coley et al. 1997; Kuo et al. 1998; Kuo 2003). Consequently, outdoor vegetation could also have implications on social health, including disease and obesity rates, and childhood activity levels (Talbot et al. 1987).

Previously mentioned studies have demonstrated that outdoor areas that include trees and green cover promote an increased level of outdoor activity and open socialization. Coley et al. (1997) observed that because both children and adults are more socially active in these areas, mixed interactions among groups also increases, promoting more child-adult time. Children in greener environments have consistently higher access to adults than in less greener spaces which can have implications on safety, crime, child development and educational achievement (Faber Taylor et al. 1998; Jacobs 1961; Kuo 2003; Kuo 2001; Kuo and Sullivan 1996; Taylor et al. 2001).

Urban trees also have the potential to improve environmental quality directly through ecological services provided and indirectly through energy conservation. Ecologically, urban trees stabilize soils, reduce runoff, sequester gaseous pollutants and particulates, and provide wildlife habitat (Sanders 1984; DeGraaf 1985; Smith 1990; Von Stulpnagel et al. 1990; McPherson 1991). Urban trees also ameliorate the adverse impacts of the 'urban heat island' through shading, evapo-transpiration, and reducing energy needs (Akbari et al. 1992; McPherson 1993).

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These noted benefits also translate into economic savings for municipalities and residents alike and can lead to a reduction in heating and cooling costs (McPherson and Dougherty 1989; McPherson 1991; Jensen et. al 2003). Trees have been shown to increase property values, increase consumer willingness to pay for goods, and increase the time a consumer spends in a shopping district (Anderson and Cordell 1988; Petit et. al 1995, Wolf 2003; Wolf 2004). Additionally, the care and maintenance of the urban forest and its benefits contributes considerably to the economy (Templeton and Goldman 1996).

The above enumerated benefits highlight the importance of urban forest monitoring and sound management. Ensuring that these benefits will be sustained through the course of anthropogenic changes in time requires monitoring trends and evaluating resources and management techniques. Urban vegetation inventories have sought to provide environmental, biological, and physical information to aid in planning and management (Gray and Deneke 1986, Miller 1988). Also, by understanding trends through time and surveying trees and their characteristics, managers are better equipped for present and future management decisions. Through the aid of a street tree inventory, managers can assess species diversity, condition, and size structure of public trees. An example from a southern California study that included street tree inventories from municipalities across the region found that, among other findings, street tree diversity is decreasing slightly (Lesser 1996). The current study will use the same tool on both public and private lands to achieve a more thorough analysis of urban forest characteristics.

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Urban Forest Comparative Analysis

The study of urban trees is unique in that it must also consider the impacts of human behavior on forest structure and composition. These influences also vary temporally with development history, spatially with patterns of land use and morphologically through intensity and design of development creating a highly heterogeneous habitat (Jim and Liu, 2001). Diversification of land use in this manner creates patterns of suitability and also preference for tree planting throughout the city. In both natural systems and urban environs, a plant's ability to survive is greatly influenced by habitat.

Though areas of natural vegetation and pre-development relics are likely to exist in most cities, trees in the urban landscape are largely the result of human selection and design. Trends in species popularity and insect and disease infestation, highlighted by the aftermath of Dutch elm disease and, more recently, in some areas of the country, emerald ash borer, are directly human associated and greatly affect urban vegetation. Because urban trees are so closely tied to the human environment, development and land use patterns contribute significantly to the age structure, condition, and species composition of the urban forest (Miller 1997; Sanders 1984a; Nowak 1994). Cultural factors such as planting policy, lot size, and the decisions of developers can influence the urban tree landscape (Dorney et al. 1984). Therefore, while the urban forest is affected by natural factors, it can also vary considerably based on temporal trends in tree and urban design preferences (Whitney and Adams 1980). Forested urban areas can be sorted into a collection of smaller forest communities characterized by similar community structure and

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and ecologic framework most easily accomplished through age stratification characterized by periods of development. Such findings can improve urban forest management by uncovering trends in forest dynamics allowing managers to better identify management zones, and by revealing ramifications of past management techniques (Brady et al. 1979).

Case studies in U.S. cities (Welch 1994; Schmid 1975, McPherson et al. 1997, McBride and Jacobs 1976, 1986,) and in China (Jim 1989; Jim and Liu 2001) have illustrated the effect of urban development history on urban forest dynamics and the potential to vary urban tree management on this basis (Welch 1994). Schmid (1975) studied tree patterns in residential areas of Chicago and found that patterns of biomass, tree placement, and species composition varied throughout the city on both public and private property. In general, these patterns were directly related to age of development and linked to socio-economic class. Varying structure and characteristics can create a smaller definable urban forest within the larger urban forest and warrant varying levels of management, a trend similar to that found in Boston, Massachusetts (Welch 1994). Street tree composition of Urbana, Illinois neighborhoods over a 50-year time span was analyzed (Dawson and Khawaja 1985). Based on the information gathered, trends in species composition were revealed and linked to management that began during the 1970's. Not surprisingly, the study found that though American elm (*Ulmus americana*) formerly dominated the public landscape, it is today nonexistent along with some other species such as box elder (*Acer negundo*) and cottonwood (*Populus deltoides*), considered in modern times to be inferior. The street tree population, though plantings seemed to decrease slightly, was becoming more diverse in comparison to the former elm monoculture (Dawson and Khawaja 1985).

Studies in Hong Kong (Jim 1989) and in Guangzhou City (Jim and Liu 2001), China have shown that development history and land use patterns have created urban districts differing in tree density and species composition. Jim (1989) found that growth conditions varied considerably throughout the five city districts he identified as representing differing phases in the 'life history' of the city.

These temporal 'phases' in the city's history should also be considered when analyzing the urban forest as a whole. Using a comparative analysis to indicate overall change through time, the ability of the urban forest to sustain its benefits can be assessed (Costanza 1995). Through a comparative analysis, patterns that may potentially be linked to management and development trends can offer insight into the sustainability, or the ability to "survive or persist", and ensure communities are better able to assess the degree of the aforesaid benefits. Because urban forests can potentially exist with so many factors that hinder growth, such as development, soil compaction, contaminants, reduced growing space, and an increased amount of private land owners, analysis of trends is imperative to an improved understanding of urban tree management (Miller 1998; USDA 1996; Nowak 1991, Nowak 1993). Though there are many factors, both social and economic, affecting the health and sustainability of the urban forest, the vegetative resource and its composition, age, and condition, is the basis of urban forest sustainability and is central to the current investigation (Clark et. al 1997; Dwyer et. al 1992).

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Planning for sustainability and long-term survival and health is essential to urban forest management and can easily be evaluated through monitoring temporal trends in urban forest characteristics (Reeder and Gerhold 1993). The dynamic nature of the urban forest influenced by both biologic (disease, soil, water availability) and artificial (trade-introduced pests, land clearing, development) change speaks for the necessity of comparative analysis. Though the importance of monitoring the urban and community forest is clearly evident, very little research exists that details trends in the overall condition of the entire urban tree populations over time (Kielbaso et al. 1993).

Urban areas include a much larger proportion of private property as compared to public property, and therefore private land use decisions made on the majority of urban land has a greater influence (Elmendorf and Luloff 1999). Urbanized and suburbanized areas also have increased numbers of stakeholders involved, each with varying objectives for their property and varying interpretations of property rights, further increasing the mosaic pattern of land use and habitat.

While most urban forest analysis has primarily focused on the publicly-owned component, an estimated 60-90 % of trees in urban areas are found on private property (Stacksteder and Gerhold 1979; Sampson et. al 1992). Because the majority of urban trees are privately owned, sustainability and health of the urban forest as a whole depends largely on homeowners and the degree to which they are informed on its roles/values (Dorney et al. 1984; Clark et. al 1997). By limiting the concept of the urban forest to public lands along streets and in parks, as commonly practiced among professional urban

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foresters, complete urban forest management and health cannot be sustained (Stacksteder and Gerhold 1979; Dwyer et al. 2000; Kielbaso et al. 1993). As a result, the definition of urban and community forest has grown beyond the previous notion that management and monitoring is necessary only on public lands to include and recognize the importance of the private landscape and private land use decisions (Dwyer et. al 2000; Elmendorf et. al 2003; Nowak et. al 2001). An all-inclusive inventory and monitoring of the urban forest is essential to improve urban forest sustainability though it is scarcely practiced and may involve increased costs to monitor and include private landholdings (Dwyer et. al 2000). Improving survival, health, and diversity of urban forests through a complete inventory of public and private lands will definitively have implications on urban forest sustainability.

Few studies have included the private component as a part of the total urban forest population and are limited to only a handful of urban locales, most notably in California, Ohio, Nebraska, and Wisconsin. In Oakland, California, both public and private trees were assessed using historical data to recreate the history of Oakland's urban forest (Nowak 1993). By using aerial photographs and historic vegetation maps, Nowak was able to include the entire urban forest without the restrictions of private property access. Estimates of species diversity and canopy cover were obtained at various points through time. However, though inclusive of private property, the study does not offer the accuracy of a ground sampling (Nowak 1993). Both public and private trees were measured throughout the City of Sacramento in urban, suburban, and rural zones (McPherson 1998). Random plots were established in the three stratified zones. The intent of this study was to determine the sustainability during the time of study of the wh

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whole urban forest and among the stratified areas by quantifying species diversity, age structure (accomplished by measuring dbh), condition, and species suitability. McPherson found that while Sacramento's urban forest is sustainable, diversity and age structure could be improved. Among street trees, 69% of all trees were represented by only eight species. Similarly low diversity results were found in all three sectors among all trees. Most trees were found to be of medium size (estimated age of 25 years) while few large trees were noted (McPherson 1998).

An urban tree survey was completed by Kielbaso et al. (1993) in the cities of Bowling Green, Ohio, and Lincoln, Nebraska and analyzed urban tree population trends including the analysis of privately owned trees. By analyzing trends over a twelve year duration, researchers were able to draw conclusions about management strategies and trends on private lands. In the case of Bowling Green, the overall condition of the tree population declined considerably in respect to that in Lincoln, a trend that is attributed to the fact that Bowling Green does not proactively manage its urban forest, while Lincoln does. The findings suggested a lack of management in Bowling Green and inferred that the presence of a city arborist and planning and maintenance department in Lincoln contributed to the success of Lincoln's urban forest.

Researchers were able to assess mortality, condition, and ratios of private and public trees and compare them to levels in 1980. The number of public trees increased over time in Lincoln while public trees in Bowling Green decreased despite an increase in private trees. Overall, the condition of trees in Lincoln declined despite proactive management.

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Though there were differing levels of management of urban trees when comparing both cities, the decline in condition is attributed to climate and the fact that Lincoln has semi-arid, prairie-like conditions, while Bowling Green is a part of the eastern deciduous forest with a more moist and favorable growing environment. Through monitoring trends in this manner, inadequacies, such as lack of public planting and the lack of a professional urban forester can be highlighted.

By utilizing a complete urban tree survey, Kielbaso et al. (1993) were able to gather a more comprehensive view of urban forest dynamics and trends over time, indicating the importance of privately owned trees. In similar manner, Dorney et al. (1984) inventoried a Milwaukee suburb. As a result, more accurate measures of trees per hectare and species composition were achieved while identifying the potential aftermath of Dutch elm disease by placing importance ratings on private tree species.

Urban Forest Attitude Surveys

Though municipal tree surveys are universally regarded as a critical component of any urban and community forestry management plan, public attitude surveys have failed to develop as a plausible technique to determine management goals and procedures. Surveying constituent attitudes and opinions on any public resource should be an integral component to management of any public resource (Dwyer et al. 2000) and can be of utmost value during times of municipal resource scarcity (Kielbaso et al. 1988, Reeder and Gerhold 1993). They can be used to identify and prioritize areas to allocate funds an

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and to evaluate the effectiveness of current management. Incorporating the community social context with urban forest management is essential to promote a sustainable public resource and can function as a two-way mechanism to relay information, and, consequently, educate the public (Dwyer et al. 2003; Clark et al. 1997). Attitude surveys can indicate to what degree the public understands the importance of trees in the community and provide insight into any inadequacies of public tree management. This kind of information can assist public tree managers to prioritize management objectives and to allocate funds accordingly by targeting management challenges. Public programs lacking constituent feedback do not completely possess the ability to evaluate, modify, and improve management. However, despite the importance of community involvement, most research and management decisions are made without regard to public preference (Kielbaso 1982).

Though important, little scientific literature examines public attitudes concerning street trees and preferences. Some studies have found trees to play a role in the visual assessment of an area. Trees are highly valued in outdoor urban areas as they affect the visual quality of residential and commercial streets and increase the appeal to residents and consumers (Kaplan and Kaplan 1989; Schroeder & Cannon 1987; Wolf 2003). This reinforces the importance of acknowledging community opinions to determine areas of need, species desired, and educational shortcomings of the public.

Trees undoubtedly have a profound effect on human environments and are an integral component of urban landscapes (Gangloff 1995; Dwyer et al. 2003; Dwyer et al. 1992).

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Research has shown a preference for forested environments and the wildlife it provides to urban residents (Getz et al. 1982; Shaw et al. 1985). Shroeder and Cannon (1987) also found that trees have a strong impact on the visual perception of streets and can influence choice of residence and potentially assist urban renewal efforts. With the increase in sprawling patterns of urban development, cities have extended their land area and influence across the landscape while affecting the viability of older urban centers, increasing the necessity for urban forests (Dwyer et. al 2003). Through survey research, managers and planners can expose attitudes on such issues and to what degree the public understands these issues.

Much survey research has been conducted to quantify the degree of benefit received through public involvement in volunteer tree planting and related activities. Surveys have found that people involved in volunteer greening projects are motivated by "deep values" such as those spiritual in nature and to find a connection with nature (Austin 2002; Westphal 1993). Findings of Sommer et. al (1994) found those who participated valued the social benefits of the urban forest and experienced feelings of empowerment and pride in neighborhood. However, though these findings provide insight into resident attitudes, they are not inclusive of the general public.

Surveys of the general public have had mixed results. Some find the concept of the urban forest intangible; therefore its benefits are not well recognized (Steigler 1990; Hull 1992). Similar to the findings of Sommer et. al (1994), Westphal (1993), and Austin (2002), residents were able to recognize the emotional significance of trees and their aesthetic

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attributes in their communities. However, residents did not fully recognize the environmental, social, and, functional benefits of trees (Hull 1992). A mail survey in Downers Grove, Illinois, found that while most residents were satisfied with the quantity and care of urban trees, less than half of the respondents were aware that a municipal forestry program existed (Schroeder and Appelt 1985).

Other surveys have suggested that the general population does value trees for a multitude of reasons and that location is also a factor. A survey conducted by a market research firm of 250 Detroit, Michigan residents analyzed preferences concerning urban trees. The face-to-face survey revealed that, only second to education, residents would prefer tax dollars to be redistributed to support parks and street trees followed by recreational programs. Trees also ranked among the most important attributes that residents value in area parks, indicating a high value placed on urban trees (Kielbaso and Karrow 1982). Similarly, Allen (1995) found that Missouri residents, regardless of region, had positive attitudes towards urban trees and were generally supportive of increased funding to support urban tree management.

Though trees were found to be important to communities overall, Kielbaso and Karrow (1982) also found that trees in various locations have varying values to residents. Relative importance of trees on government-managed streets, open park areas, and wooded areas were measured on a five-point scale. Respondents listed tree-lined streets to be the most important location for government managed trees, followed by open park areas, and wooded areas. The survey further weighted the relative importance of trees in a v

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a variety of general locations typical in cities. Again, residential streets ranked highest, followed by city parks, and front yards. Of least importance were industrial areas and parking lots (Getz, et al. 1982; Kielbaso and Karrow 1982). Knowledge of similar preferences can help best effectively manage today's urban forest.

Kalmbach and Kielbaso (1979) also found that, contrary to some current practices, residents prefer large street trees as opposed to smaller trees when only aesthetics are considered. Additionally, 59% of residents preferred increased street tree densities, at a rate of one tree per urban lot, and residents generally agree that trees improve the urban environment.

Residents of the largest metropolitan areas in the U.S. were sampled via telephone interview (Lohr et al. 2004). Their findings indicate that most residents (83%), regardless of demographics, throughout the United States value trees and rate them as a contributing factor to quality of life. Those who did not find trees important to the quality of life in the community were likely young (between the ages of 18-21), and/or poorly educated, suggesting education plays a role in urban resident attitudes towards the environment and street trees.

Residents placed a high value on the function of trees, particularly their capacity to cool and shade downtown areas (Hull 1992; Stiegler 1990). Other reported values of trees were calming properties and smog, dust, and noise reduction. Respondents were more able to identify positive features of streets trees rather than annoyances and found most attributes of urban trees commonly thought of as annoyances inconsequential (Lohr et al. 2004).

STUDY SITE

Grand Junction, Colorado, USA

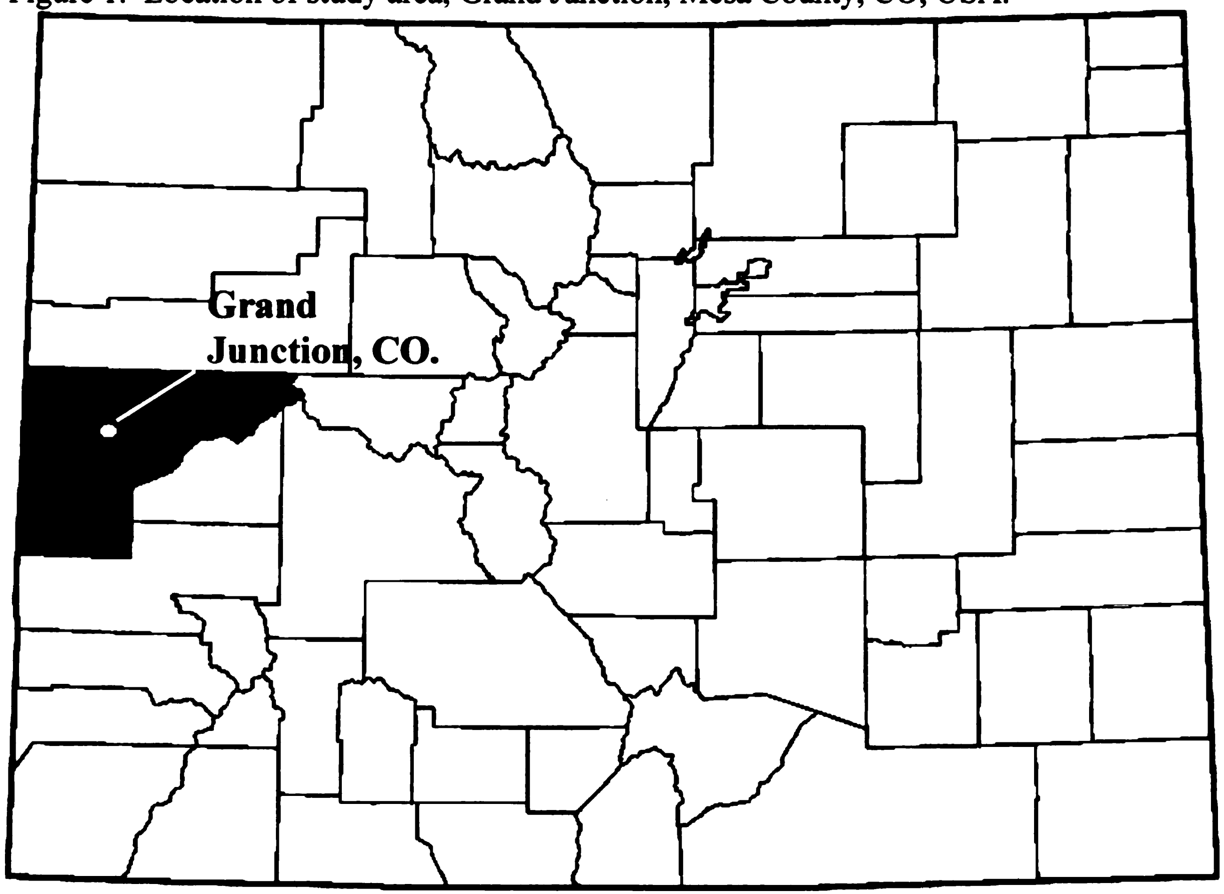
History

The city of Grand Junction, Colorado was established at the confluence of the Grand (now known as the Colorado River) and Gunnison Rivers in western Colorado, 28 miles east of the Utah border. Settlement occurred in the early 1800's and was prompted by the discovery of gold and silver in nearby mountains. Before its incorporation on October 10, 1881, the site was home to the Northern Ute Reservation. This native American tribe was later relocated to western Utah. Once established, the town was named Ute after the native population and was later changed to West Denver. The town was later renamed Grand Junction for its location at the confluence of the Grand and Gunnison Rivers.

Geography and Demographics

The city is located in what is known as the Grand Valley at an elevation of 4,586 feet (1397.8 m.) above sea level. It has a mean annual temperature of 51.8° F (10.55° C) and a mean annual precipitation of 8.99 inches (22.83 cm.) and mean annual

Figure 1. Location of study area, Grand Junction, Mesa County, CO, USA.



http://commons.wikimedia.org/wiki/Image:Map_of_Colorado_highlighting_Mesa_County.svg

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snowfall of 22.0 inches (55.88 cm.). The Grand Valley is surrounded by mesa and mountains to the north, south, and east, most notably, the Grand Mesa, the city's most distinctive landscape feature. Today, the city occupies a land area of 26.47 square miles (42.6 sq. km.).

Grand Junction serves as the largest regional hub between Denver, CO and Salt Lake City, UT. It serves as Mesa County Seat and home of Mesa State College. According to the 2000 U.S. census, the larger Grand Junction Metropolitan Statistical Area (including the nearby suburban communities of Fruita and Palisades) has a total population of 116,255, the fifth largest in the state of Colorado and the twelfth fastest growing in the southwest United States. Grand Junction proper has a population of 41,986, 48.7% male and 51.3% female. The median household income is $33,152. The majority of the population (57%) is employed by service or retail related industry. Though there is some light industry, only 8% of the population is employed by the manufacturing sector.

The Grand Mesa Region

Mesa County was created from existing neighboring counties in 1883 and is located 250 miles west of Denver at the Utah / Colorado border and occupies 3,309 square miles. Seventy-two percent of Mesa County is publicly-owned, primarily by the U.S. Forest Service, the Bureau of Land Management, and the State of Colorado. The Colorado National Monument and Colorado River State Park are both within close proximity to Grand Junction. The Grand Mesa National Forest, named after the mesa j

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of the same name and the largest flattop mountain in the world, also neighbors the city. Surrounded by unique landscapes, mesas, lakes, and mountains, the region has become a tourist destination. Studies indicate that tourism accounts for 17% of all jobs and 11% of income in Mesa County.

Because annual precipitation rates are among the lowest in the state, vegetation in the region differs greatly from other regions. Generally speaking, pre-settlement vegetation was characterized by scrub oak, sage, juniper, cedars, and pinyon pines with cedars more prevalent at lower elevations. In areas of higher elevation, pockets of aspen are also dispersed throughout the landscape mixed with some pines at the highest elevations. Cottonwoods, honeysuckle, and buffalo berry are commonly found along streambanks (Robbins 1910).

Due to the limited amount of rainfall, irrigation was introduced by barrels in 1894, and in 1913 a mass irrigation system was developed by the U.S. Government. The mild climate, an exceptionally long growing season of approximately 182 days (the longest in the state), and ideal terrain, once irrigated, has perfectly suited the area for crop production (Robbins 1910). Known locally as the "banana belt", with the aid of irrigation, conditions are ideal for fruit crops and have earned Grand Valley the title of "Colorado's wine country". Much of the surrounding land is dedicated to crop production and orchard fruit production (Baker 1932).

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During the last decade, the region has experienced significant growth and development with a growth rate among the top 10% of counties nationwide. From 1990 to 2000, Mesa County's population grew by 24% and is projected to reach 143,591 by 2010 (an increase of nearly 23% from 2000).

Industry

Industry has historically played a significant role in shaping Grand Junction's development. Because of its location on key railroad and transportation routes, the city began to expand quickly soon after establishment. The first industries in the area centered on gold and silver mining. Vanadium, a soft, rare metal used to produce certain alloys, was discovered and mined throughout the Colorado Plateau region. Early in the 20th century, vanadium mining increased heavily as a result of wartime demand and quickly became the community's most lucrative business. During the process of vanadium mining, uranium was often discarded as waste. Uranium mining, for which no regulation was mandated at the time, later replaced vanadium in demand due to the Cold War and efforts of the Manhattan Project (Energy 1995).

In 1950 the Climax Uranium Company entered into contract with the U.S. Atomic Energy Commission and commenced development of a 200 acre uranium mill site. Located on the bank of the Colorado River within the city of Grand Junction, the mill produced uranium and vanadium compounds during 1951-1970. In the duration of operation, the mill produced 11.7 million pounds of U_3O_8 (uranium "yellowcake") and 46.1 million pounds of V_2O_5 (vanadium). Once decommissioned, portions of the site were converted for industrial park use while other areas were ceded to the state. Ten acres were sold as private property (U.S. Department of Energy 2002).

Though the site has been inactive for over 30 years, remediation has been a continuing process. Uranium mill tailings from the Climax mill were available to the public and were used throughout the community in the construction of private residences, churches, commercial properties, and schools. An estimated 300,000 tons of radioactive mill tailings were distributed to the public during the 1950s and 1960s. The widespread use of uranium mill tailings for backfill and as a sand substitute was deemed hazardous in 1972, and remediation efforts were initiated by both state and federal governments (U.S. Department of Energy 2002; Long-Term Surveillance and Monitoring Program). Tons of waste tailings were excavated from four-thousand, two hundred homes and relocated to a 40 acre temporary containment site (Miller 2002; U.S. Department of Energy 2002). The actual number of homes and other sites constructed with radioactive materials is unknown. Despite a 25 year public campaign to locate and eradicate residual uranium mine tailings, up to one million cubic yards of tailings are estimated to still be dispersed throughout neighborhoods in the greater Grand Junction region (U.S. Department of Energy 2002; Long-Term Surveillance and Monitoring Program 1999)

Remediation of the Climax mill site did not begin until late 1988. Remaining buildings were removed and a 98 acre disposal cell in the town of Whitewater, ten miles southeast, was prepared to receive and consolidate contaminated materials, tailings, and dirt (Miller 2002; U.S. Department of Energy 2002). The Cheney disposal cell now houses radioactive mill tailings previously dispersed throughout the city and waste removed from the original Climax site. Approximately 4.4 million cubic yards were relocated to the disposal cell. The mill site was restored with clean backfill, a wetland was established in 1994, and the site was declared 'clean' by NRC in 1997 (U.S. Department of Energy 2002).

Though uranium and its residues have been, and continue to be, present in unknown amounts throughout the region, there is little documentation on their adverse effects in the community. Accounts from mines located across the Colorado Plateau recount stories of uranium trucks at the height of the boom recklessly transporting product to maintain pace with demand. Uranium particulates were part of the dust liberally added to the air from trucks, equipment, and open mines. Streams leading from mines moved these sediments across the region. Those employed and, through exposure from construction materials, those not employed by uranium mines were exposed to constant radiation. Sheep and cattle herds were lost due to defective births and children and families played adjacent to mines and buildings constructed with low-grade mine waste (Navajo 1997). Career uranium mine workers have developed otherwise inexplicable forms of respiratory problems (Mulloy et. al 2001). Though these tails are abundant throughout the region, there is little research available linking the uranium mine industry with adverse human or biotic life effects (Geiger et. al 1992), with the exception of radon and gamma radiation exposure (Uranium 2000). This is due in part to government encouraged secrecy of uranium mining related to Cold War efforts (Easthouse 1996; Brocious 1993). While the effects of mining in the area are yet to be quantified, little evidence exists to suggest any adverse effects on local vegetation.

Other than the documented effects of radon and gamma radiation, there is no link to the adverse effects of the mining industry's presence in Grand Junction, though there is evidence of environmental degradation. Yearly sampling of test wells revealed water levels with excess amounts of molybdenum, uranium, and alpha radiation that has slowly infiltrated to the Colorado River (U.S. Department of Energy 2002).

Following the uranium boom, the area experienced another period of growth from development of oil shale found on the western slope. Grand Junction began to develop rapidly and focused economic interests in the oil business. This eventually subsided and left many in the area economically depressed. The city has since diversified its economy and plays a key role in regional trade, services, transportation, health care, and education. Because of its prime location, adjacent to Interstate 70 and nearly midpoint between Denver and Salt Lake City, Grand Junction has become an important regional distribution and service center. Regional airport and train facilities have also played a role in Grand Junction's service-based growth.

Despite economic growth, over 52% of the city's jobs are concentrated in traditionally lower-paying sectors, such as retail and services. Additionally, the population growth has far exceeded the growth of available affordable housing. Housing costs have increased as much as 207% while wages have increased just

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46.3% over a duration of just ten years. However, developers have continued to cater to the wealthy by concentrating on more expensive homes.

Development and Urban Planning

Boom and bust growth cycles spurred by the previously mentioned industries have shaped growth patterns throughout Grand Junction and the greater Grand Mesa region. Periodic cycles of growth resulting from booms in industry encouraged haphazard development. Many subdivisions were poorly planned without regard for future costs and without regard to long-term sustainability (City of Grand Junction, 2003). Utilities and roadways were extended and established to create a pattern of sprawling development and a financial burden (City of Grand Junction, 2003). In these boom periods, high demand for housing led to relaxed development standards that are now evident in some of the city's oldest and most economically depressed areas (City of Grand Junction, 2003). Outlying agricultural lands and open space that have historically lured residents to the area have quickly diminished, converting farmland and orchards to crammed subdivisions often devoid of urban trees (City of Grand Junction, 2003).

The cyclic pattern of growth in the city has created a town plan that was influenced by the land use designs popularized during several eras. Urban planning and design standards and trends have varied considerably with time and have created land use patterns of various designs and frequencies. The current period of rapid growth centered on automobile convenience has imprinted a large pattern of cul-de-sac style and large commercial areas of 'big box' developments with a high level of impervious surfaces that are inhospitable to tree growth (City of Grand Junction, 2003; Nowak et al. 1996).

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MATERIALS AND METHODS

Background

Urban forest data were collected by the United States Forest Service to determine trunk size, species composition, and tree condition, and other variables related to trees and land use in ten cities throughout the United States during 1979-1980. The cities included (in alphabetical order): Bowling Green, Ohio; Bucyrus, Ohio; Charlottesville, Virginia; Delaware, Ohio; Grand Junction, Colorado; Hutchinson, Minnesota; Jamestown, New York; Lincoln, Nebraska; West Springfield, Massachusetts; and Wooster, Ohio. These data were originally intended to identify the effects of Dutch elm disease *(Ophiostoma ulmi)* in communities representing various ecological units and subunits across the US (Kielbaso 2002) as described by Bailey et al. (1994) and McNab et al. (1994).

The study collected data on both public and private property and delineated three separate age classifications of development within each city. These baseline data were unique in that components of the urban forest, both under public and private ownership, are analyzed. Because both components are inventoried in each locale, the data offer a more complete portrayal of the urban forest than previously studied, providing a unique vantage into each city's urban forest during those years sampled. Due to its unique nature, the data originally collected from all ten cities was analyzed, and a summary of results can be found in Appendix A.

While the sampling of cities during 1979 and 1980 offers only one perspective dated 25 years, data from these years offer a unique opportunity to investigate trends over the duration. The city of Grand Junction, CO was selected as the primary research city because of its unique development history to investigate trends in the urban forest composition among three characteristics of sustainability: size, condition, and species diversity. These variables were studied on both public and private property and within neighborhoods of delineated age classifications to consider the patterns and effects of development on the aforementioned characteristics (McPherson 1998).

1980

Study Design

Each selected city was stratified by the United States Forest Service researchers in the original study from 1980 into three age classes of development representing age of construction: Class A (0-10 years), Class B (11-40 years), and Class C (40+ years). Stratification by age of development assumed that residential areas of similar age would reflect similar forest composition and results could be extrapolated by age of development (Whitney and Adams 1980). Whitney and Adams (1980) also found that the forest complex of developments constructed post World War II differ from those constructed before and from those constructed some time following the war. A third variance was noted in developments constructed some time since WWII that emphasized the 'American myth' of rural life, commonly regarded as suburban flight (Whitney and Adams 1980)

These classifications were used to delineate age class stratification. Three replicates (one replicate was considered one city block) were established in each stratum for a total of nine study blocks, recommended to achieve accurate data collection with minimal time input (Kielbaso et al. 1993). Experimental design in all ten cities was stratified in the same manner, described in more detail in 2004 (pg. 33).

Data were recorded for all trees on each block noting the location of each as on either public or private property. Information was also manually recorded on the property and individual tree details including: maintenance, lot dimensions, species, trunk diameter, tree height, crown diameter, percentage of crown exposed to sunlight, and tree condition.

Species Diversity

Trees were identified to genus and species for each tree recorded. Because access was limited on many private properties, accurate identification was more difficult. Some trees are identified only to genus, including all elms (*Ulmus*) and ash (*Fraxinus*). General identification of ash and elm species, now threatened by disease and/or insects, and consequently of low future interest, does not affect diversity measures as it was employed in all circumstances and indices will all be affected accordingly (Dorney et al. 1984).

Unidentifiable species were listed as unknown. In some circumstances, enough information was available to identify to genus (for example, *Acer*, or maple, rather than unknown).

Tree Condition

Rating tree condition across a gradient of degrees is commonly done in studies that include private property (McPherson 1998). Because tree condition is often a subjective rating and can overlook some symptoms of poor health and condition, a system that assessed the trunk, crown, and root components of individual trees was developed by researchers for the original 1980 study. This method focused on diagnostic signs in order to assign a condition classification (Table 1) and allowed for an efficient yet reliable method that was easily mastered by novices (Kielbaso et al. 1993). Table 2 was used to determine a condition rating based on the number of condition compromising signs present.

Table 1. Guide for assessing condition rating of inventory trees, Grand Junction, CO.

Crown	Main stem/branches	Base and Roots
Size	Signs of decay or wounds	Decay
Color of foliage	Broken main branches	Girdling roots or absence of trunk flare
Density of foliage	Signs of improper pruning	Roots severed over 25% circumference
Shoot size after pruning	Bark overgrowths	Damaged roots showing scars, over 25% circumference
Dead branches and twigs	Dark streaks in bark	75% root area covered with impervious material

Table 2. Chart for determining condition rating of trees inventoried in Grand Junction, CO.

Condition	Condition Signs	Rating
1	0 - 1	Excellent
2	2	Good
3	3 - 4	Fair
4	5	Poor
5		Dead

Tree size

Because of the access limitations of some private property, tree size was recorded as a categorical value. Table three lists the diameter classes used to denote size.

Table 3. Size classifications of trees measured, Grand Junction, CO.

Size Class	DBH (inches)	Category
1	< 4	Sapling
2	4-10	Small tree
3	11-16	Medium tree
4	> 16	Large tree

2004

Study Design

The city of Grand Junction was stratified into three age classes of neighborhood just as it was in 1980.. As 24 years had passed since initiation, Age Class A, which originally included only ten years, was expanded to accommodate newer developments. Though it was not composed of developments within an identical duration in both 1980 and 2004, Age Class A represents 'newest' developments with common development patterns created under similar conditions in both study years. Age stratifications were intended to classify urban developments among 'newest', 'middle-aged', and 'oldest' for one point in time and also represent trends in urban design. As the original delineation for 'new' developments spanned only 10 years, including the most recent 24 years distributes age classifications more evenly throughout the development history of Grand Junction. Additionally, urban planning and growth patterns were not considered to have changed considerably from the 1980 study, in which Age Class A included neighborhoods developed in 1970-1979, to that included in 2004. Age classes of stratification are given in Table 4.

Table 4. Age class stratification of neighborhood developments in Grand Junction, CO.

Age Class	Age in 1980 (yrs)	Age in 2004 (yrs)
A	0-10	0-34
B	11-40	35-64
C	41 +	65 +

For this analysis, five plots were randomly selected for inventory in each strata for a total of 15 blocks overall. Selection was independent of the original sample blocks as those studied in 1980 could not be located based on the information available. Data were collected on species, tree ownership, trunk size, and tree condition.

Species Diversity, Condition, and Tree Size

Species diversity and condition were assessed in a manner identical to that done in 1980. Size of trees was measured as diameter at breast height (dbh - 4.5 feet above ground). Because trunk diameter can be used as an estimate of height and crown diameter, and is the standard measurement for most urban forest management, it was the only size measurement considered (Kielbaso et al. 1993). In most instances, additional size measurements of crown spread and tree height were limited due to lack of access on private property. Because access to private property was inconsistent, dependent on whether a resident was present and granted access, exact diameter measurements were not used. Instead, diameters were classified into four size categories listed in Table 5.

Table 5. Size class delineations for trees on public and private property, Grand Junction, CO, 1980-2004.

Size Class	Diameter	Category
1	< 4	Sapling
2	4-10	Small tree
3	11-16	Medium tree
4	> 16	Large tree

Survey of Resident Attitudes

Attitudes of residents towards urban trees were also studied. Residents in all three residential age classes whose neighborhoods were inventoried for the 2004 sampling received a survey.

Questionnaire

Because each neighborhood block and, consequently, each age classification varied in the number of households, data were presented proportionally. The survey used was developed by De Araujo (1994) after review of similar surveys and methodologies to determine attitudes towards urban trees in Curitiba, Parana, Brazil and modified for this study. Most questions were closed format, asking for only a yes/no/maybe response, order ranking, or a check mark. Though a few questions were open-ended, the survey overall required very little written response. The survey can be found in Appendix H.

Residents were asked to evaluate neighborhood trees, defined as those growing within a one to two block radius from their house, business, apartment, etc. They were asked to rate the degree of benefit they received relating to 14 possible positive features. Fourteen possible annoyances commonly reported for street trees were also rated. Responses were limited to: no benefit / annoyance (1), slight benefit / annoyance (2), some benefit / annoyance (3), great benefit / annoyance (4), very great benefit / annoyance (5). The importance of trees in seven possible locations throughout the city, including, city parks, downtown shopping areas, residential streets, backyards, etc, was rated in the same manner; very important (1), greatly important (2), somewhat important (3), slightly important (4), or not important (5).

The survey also asked general questions about trees throughout the city. Residents were asked to rate the overall condition of street trees, the size of street trees, the pruning of street trees, and the maintenance of street trees with a multiple choice scale ranging from excellent (1), very good/well (2), good/well (3), poor (4), very poor (5).

Additionally, the survey probed resident willingness to pay or participate in several ecologically related activities/programs. Residents responded yes, no, or maybe and whether they would be willing to pay to enhance city services, such as parks, recreational programs, street trees, and environmental education. They were also questioned regarding their willingness to participate in ecological related activities, such as Arbor Day celebrations, environmental education, and volunteer service. Participants were also provided a list of general potential planting locations throughout the city and asked to prioritize them by area most in need of tree planting. They were also asked if more trees should be planted in Grand Junction.

A list of general statements was given and recipients were asked to rate to what degree they concurred. A gradient scale of strongly agree (1) to strongly disagree (5) was used. Statements generally related to the quality of life and urban planning of the city and included: 'The city is a model of urban planning', 'Trees contribute to the quality of life in the city', 'My neighborhood is well-planned', 'The city is ecologically conscious'. A complete survey is provided in Appendix G as well as copies of postcard mailings.

Lastly, demographic information regarding gender, age, level of education, household income, home ownership, and length of time at residence was included in the survey. The survey indicated this information would be used for statistical purposes only.

Survey Procedure

During data collection in 2004, residents and businesses on the same randomly-selected blocks were left with notification that a survey would be mailed to them asking their opinion on trees in Grand Junction. Notices were either given directly to residents or left on porches for those who were not home. One week prior to mailing the survey, a postcard was sent to each address, as one year had passed since initial notification. The survey was mailed in October of 2005 and included an addressed and stamped return envelope, the survey, and a one-page cover letter including a brief summary of the research and its importance. Surveys were printed double-sided on two sheets of white 8.5 x 11-inch paper, stapled, and letter-folded. Because a city-provided resident listing of homeowners in sampled neighborhood blocks only supplied the names of actual owners, not potential renters and others living at the address, survey recipients were simply addressed as "resident". Similar surveys did not find this to have an effect on return rate (Sommer et al. 1989).

To ensure the best possible return rate, a record of surveys returned was kept using a system of coding on the stamped return envelopes. Each recipient address was provided with an addressed return envelope coded to identify the return address. A second reminder postcard preceded the surveys and was mailed to addresses that had not yet responded. Addresses that did not reply to the initial survey received an identical second survey four weeks following the first mailing. An additional four weeks was allowed, a total duration of eight weeks, for return of respondent surveys.

Data analysis

Analyses were completed for data sets in both 1980 and 2004 within the city of Grand Junction to determine whether neighborhood age or tree ownership had influenced the characteristics of interest at those points in time. For both years, comparisons were drawn within the sample year for tree characteristics between public and private ownership and between age class of neighborhood to identify statistical differences based on ownership or age of development. Overall analysis of each measured characteristic was completed for 1980 and 2004 to identify trends over the 24 year time period. As the survey was not included in the 1980 study, analysis of urban tree attitudes was done only in 2004 and compared attitudes of residents among the three identified age classes of neighborhood.

Using the 1980 sampling, including all other sampled cities, analysis was completed to determine if Grand Junction was similar to other cities sampled in regard to species diversity, tree size, and tree health among public and privately owned trees and among neighborhoods of varying age. Data was analyzed using JMP IN version 5.1 statistical package from SAS software using non-parametric statistical tests.

Species Diversity

Because access limited accurate species identification on many private lots, some species were identified to genus. For example, although many trees were identified as white ash or green ash, there were a number of trees that, due to limited access, were identified simply as 'Ash spp'. For this reason, both green ash and white ash were categorized as 'ash'. Species diversity was calculated using Shannon's Diversity Index (H) as given below:

$$H = -\sum_{i=1}^{s} p_i \log p_i$$

where p_i equals the proportion of the total number of specimens (*i*) expressed as a proportion of the total number of species for all species present. The product of p_i and $\log p_i$ for each species is summed and multiplied by negative one to create a positive value.

Because the Shannon index is relative, it is used only on a comparative basis. Statistical analysis was performed on these values using the Tukey-Kramer HSD test, or honestly significant difference for multiple variables and a Student T-test for those variables with only two.

Size and Condition

As tree size and condition variables of both public and private trees are categorical response variables, they were analyzed using frequency tables and performing a Pearson chi-square analysis using the formula presented below:

$$\chi^2 = \frac{(O - E)^2}{E}$$

where O is the observed frequency for the variable and E is equivalent to the expected frequency of each variable under the assumption of independence.

Survey Response

Although the questionnaire used was a slightly modified version of that used by De Aruajo (1994) to assess resident attitudes in Curitiba, analysis of only selected questions is presented. Some questions that were questionably appropriate for the study have been omitted because of their relativity to the study. While important to the study in Curitiba, this study focused more on physical features of the urban forest rather than centering entirely on resident attitudes. Additionally, some questions received such a poor response rate that they could not be analyzed. Questions analyzed included questions 1, 3, 5, 6, 7, 8, 9, and 14 are listed in Table 6.

Table 6. List of survey questions included in 2004, Grand Junction, CO.

Question #	Relevant content
1	Positive benefits of street trees
3	Negative features of street trees
5	Overall opinion of street trees in neighborhood
6	Size of street trees in neighborhood
7	Pruning of street trees in neighborhood
8	Rating of city tree maintenance
9	Should more trees be planted?
14	Demographic information

Survey questions were not statistically analyzed for significance as the small sample rate did not permit reliable results (Kuehl 2000). Instead, analysis of the questions listed in Table 6 was limited to response percentages and mean ratings. While this does not provide definitive statistical results that can determine significant differences in attitudes among neighborhood, it may give useful information on trends in each neighborhood.

RESULTS

Analysis within the City of Grand Junction, 1980

Species Diversity

Overall analysis of species diversity, including both public and private properties, within the three age classifications of neighborhood finds no difference exists with age of neighborhood in 1980. Table 7 presents the mean species diversity and standard error in each age class as well as on public and private property in each age class. No differences in diversity were found between private properties in the varying neighborhood classes. Similarly, diversity on public property was similar in all age classes. A list of the most common species found in each age class is given in Table 8.

Table 7. Mean species diversity indices and standard errors of public and private forest component, Grand Junction, CO, 1980.

	1980					
Neighborhood age class	Overall		Public		Private	
	n	$\bar{x} \pm \sigma$	n	$\bar{x} \pm \sigma$	n	$\bar{x} \pm \sigma$
A (0-10 yrs.)	6	1.64 ± 0.463	3	0.67 ± 0.378 *	3	2.61 ± 0.069 *
B (11-40 yrs.)	6	1.72 ± 0.429	3	0.78 ± 0.161 *	3	2.65 ± 0.149 *
C (41+ yrs.)	6	1.89 ± 0.257	3	1.33 ± 0.085 *	3	2.46 ± 0.053 *
All	18	1.75 ± 0.215	9	0.93 ± 0.154 *	9	2.57 ± 0.058 *

* Statistically significant between public and private property ($p = 0.05$).

Table 8. Five most prevalent species, Grand Junction, CO, 1980.

Age Class A: 0-10 yrs.			Age Class B: 11-40 yrs.			Age Class C: 41 + yrs.		
Species	n	% pop.	Species	n	% pop.	Species	n	% pop.
Malus spp.	45	14%	*Fraxinus spp.*	60	20%	*Ulmus spp.*	48	18%
Fraxinus spp.	35	11%	*Ulmus spp.*	29	10%	*Fraxinus spp.*	37	14%
Salix spp.	32	10%	*Ailanthus altissima*	27	9%	*Ailanthus altissima*	36	13%
Populus tremuloides	29	9%	*Juniperus scopulorum*	24	8%	*Juniperus scopulorum*	26	10%
Pinus nigra	23	7%	*Populus nigra var italica*	22	7%	*Platnus occidentalus*	21	8%
Total		50%	Total		54%	Total		62%

Though diversity did not differ among age classes of development, differences in species diversity were found between private and public forests in all age classes. In the most recent developments, Age Class A, mean public species diversity (0.67) was far lower than that of its privately managed counterpart (2.61). Mean diversity in Age Class B and Age Class C was also significantly lower (0.78, 1.33, respectively) on public property than on private (2.65, 2.57, respectively) property. Overall diversity of public property, inclusive of all neighborhoods, (mean = 0.93) was also significantly lower than that on private property (mean = 2.57).

Tree Size

Size of urban trees was measured throughout the city in neighborhoods of varying age (areas 0-10 years old, 11-34 years old and 35+ years old) on both public and private property and analyzed using a chi-square test on the frequency of occurrence in each age class and on public or private property. Chi-square values as well as percentages of the sample population are presented in Table 9.

Chi-square analysis indicated that an overwhelming majority of trees (90%) found in the youngest neighborhoods were saplings, identified as trees under 4 inches in diameter. While 59% of all saplings were present in the newest developments, only 15% and 26% of total saplings were in the oldest and middle-aged neighborhoods, respectively. Because of the high frequency of saplings in the most recent developments, and consequent low frequency in oldest developments, both were found to be highly significant.

Table 9. Chi-square test probabilities comparing size of trees in neighborhoods of varying age, Grand Junction, CO, 1980.

		Tree Size								
		n	< 4 in.	n	4 - 10 in.	n	11 - 16 in.	n	> 16 in.	Σ
Age of development	A: 0-10 years	298	66.88 ***	29	19.59 ***	4	32.02 ***	1	39.48 ***	332
	% trees in age class	90%		9%		1%		0%		37%
	% trees in size class	59%		16%		4%		1%		
	B: 11-40 years	132	8.30	69	1.80	59	14.63 **	42	0.49	302
	% trees in age class	44%		23%		20%		14%		33%
	% trees in size class	26%		39%		55%		37%		
	C: 40 + years	78	36.11 ***	78	12.14	45	4.96	70	38.65 ***	271
	% trees in age class	29%		29%		17%		26%		30%
	% trees in size class	15%		44%		42%		62%		
Σ		508		176		108		113		905
		56%		19%		12%		12%		

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 6

Because a significantly higher frequency (90%) of trees in neighborhoods developed within 0-10 years of the original sample were found to be saplings, the frequency of trees in all other size classifications was found to be significantly lower. Small trees, those with a diameter of 4-10 inches, comprised only 9%, compared to 23% and 29% in Age Class B and C, respectively, of trees while medium-sized trees composed only 1% compared to 20% and 17% in Age Classes B and C, respectively. Not surprisingly, large trees, those with a diameter of over 16 inches, made up less than 1% of trees in these neighborhoods.

Though the urban forest in neighborhoods that were developed between 11 and 40 years (Age Class B) from the sample period had a more even distribution of tree size compared to newer developments, a significantly higher frequency, 55% compared to 4% in Age Class A and 42% in Age Class C, of all medium-sized trees (11-16 inches in diameter) was found.

Within neighborhoods over 41 years in age, tree size was fairly evenly distributed. Table 9 shows that 29% of trees in these neighborhoods were saplings, 29% small trees, 17% medium trees, and 26% large trees. While there are no significant differences in the frequency distribution of size classes throughout the neighborhood, differences do exist when compared to younger neighborhoods. For example, only 15% (highly significant at the 0.005 level) of all saplings found in the 1980 sampling were located in the oldest neighborhoods. Similarly, 62% (highly significant at the 0.005 level) of trees over 16 inches in diameter were found in these neighborhoods. Table 10 presents chi-square analysis of difference in size of trees between public and private property, inclusive of all

Table 10. Chi-square test probabilities comparing size of trees on public and private property in Grand Junction, CO, 1980.

		Tree Size								
		n	< 4 in.	n	4 - 10 in.	n	11 - 16 in.	n	> 16 in.	Σ
Ownership	Private	478	7.72	143	0.06	54	14.08***	75	3.71	750
	% trees in owner. class	64%		19%		7%		10%		83%
	% trees in size class	94%		81%		50%		66%		
	Public	30	37.35***	33	0.27	54	68.14***	38	17.97***	155
	% trees in owner. class	19%		21%		35%		25%		17%
	% trees in size class	6%		19%		50%		34%		
Σ		508		176		108		113		905
		56%		19%		12%		12%		

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 3

neighborhoods. Again, frequency of saplings (trees under 4 inches dbh) was found to be significant with the majority, 94% of all saplings, found on privately owned lands while only 6% were located on publicly managed lands. Additionally, saplings comprised the smallest percentage of trees on public property, only 19% of public forest composition.

Frequency of medium-sized trees (11-16 inches in diameter) was found to be significant on both public and private property (Table 10). Medium-sized trees were significantly lower on private property, only 7% of all trees on private land. The opposite was found for public land with medium trees accounting for the majority, 35% of public forest composition. Frequency of the largest trees, those with a diameter of over 16 inches, was also found to be highly significant on public lands. Only thirty-four percent of all trees this size was reported on public lands in comparison to sixty-six percent on private property.

Tree Condition

Overall analysis comparing condition of trees between neighborhoods (Table 11) yielded little difference, with the only significant difference found in the youngest neighborhoods. Seventy-seven percent of all trees in Age Class A were identified as being in excellent condition, significantly higher than that found in all other condition classes. While a significantly higher proportion of trees were found in excellent condition, only 2% of trees in Age Class A were observed in poor condition. Those trees constituted only 7% of all trees in poor condition, most being found in Age Classes B

(47%) and C (45%). No differences were noted in the condition analysis of tree frequency in both Age Classes B and C.

Frequency of tree condition on public and private property in 1980 is reported in Table 12. Of all trees recorded in excellent condition throughout the city, only 10% were publicly-owned with the majority (90%) found on private property. Additionally, a high percentage of public trees, 27%, were assessed in poor condition. Of trees publicly managed, only 32% were found in excellent condition and 21% in good condition compared to 62% of private trees in excellent and 16% in good condition. A higher frequency of public trees was also found to be in poor health or dead. Twenty-seven percent of public trees were in poor health compared to 8% of private trees and 6% of public trees were dead compared to only 3% of private trees. While this does not present a positive image of city management of public trees, it should be noted that only 6% of public trees were dead and a combined total of 53% of trees were in good or fair condition.

Table 11. Chi-square test probabilities comparing condition of trees in neighborhoods of varying age, Grand Junction, CO, 1980.

		Tree Condition										
		Excellent		Good		Fair		Poor		Dead		Σ
		n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square	
Age of development	A: 0-10 years	257	25.16 ***	45	2.34	15	14.05	7	23.67 ***	8	1.82	332
	% trees in age class	77%		14%		5%		2%		2.41		37%
	% trees in cond. class	50%		29%		14%		7%		22.86		
	B: 11-40 years	138	6.43	66	4.15	36	0.05	47	5.90	15	0.94	302
	% trees in age class	46%		22%		12%		16%		4.97		33%
	% trees in cond. class	27%		43%		35%		47%		42.86		
	C: 40 + years	118	8.26	43	0.21	53	15.34	45	7.95	12	0.22	271
	% trees in age class	44%		16%		20%		17%		4.43		30%
	% trees in cond. class	23%		28%		51%		45%		34.29		
Σ		513		154		104		99		35		905
		57%		17%		11%		11%		4%		

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 8

Table 12. Chi-square test probabilities comparing condition of trees on public and private property in Grand Junction, CO, 1980.

		Tree Condition										
		Excellent		Good		Fair		Poor		Dead		Σ
		n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square	
Ownership	Private	463	3.37	121	0.34	84	0.06	57	7.64	25	0.55	750
	% trees in owner. class	62%		16%		11%		8%		3%		83%
	% trees in cond. class	90%		79%		81%		58%		71%		
	Public	50	16.32 ***	33	1.66	20	0.27	42	36.99 ***	10	2.68	155
	% trees in owner. class	32%		21%		13%		27%		6%		17%
	% trees in cond. class	10%		21%		19%		42%		29%		
Σ		513		154		104		99		35		905
		57%		17%		11%		11%		4%		

* p = 0.05
** p = 0.01
*** p = 0.005

DF=4

Analysis within the City of Grand Junction, 2004

Species Diversity

Similar to that found in 1980, species diversity is significantly higher for the privately-owned component (2.29 ± 0.127) of the urban forest in comparison to the public component (0.45 ± 0.188, Table 13). However, unlike that found in 1980, the diversity is significantly higher on private land in Age Classes A and B but not in Age Class C where no difference was found between private diversity (1.87 ± 0.208) and public diversity (1.24 ± 0.348). However, public diversity, though low, in Age Class C is statistically higher than that found in both Age Classes A (0.10 ± 0.100) and B (0.00 ± 0.000). Private diversity also differs among the three age classes of development. While diversity did not differ between Age Class A (2.44 ± 0.206) and C (1.87 ± 0.208), C was significantly lower than that in Age Class B (2.58 ± 0.107). The most common species in each age class are given in Table 14.

Table 13. Mean species diversity indices and standard errors for all sample areas in Grand Junction, CO, 2004.

	Shannon Index					
	Overall		Public		Private	
Age of neighborhood	# of blocks	$\bar{x} \pm \sigma$	# of blocks	$\bar{x} \pm \sigma$	# of blocks	$\bar{x} \pm \sigma$
A: 0- 34 years	10	1.27 ± 0.404	5	0.10 ± 0.100 [a]	5	2.44 ± 0.206 [a]
B: 35 - 64 years	10	1.29 ± 0.433	5	0.00 ± 0.000 [a]	5	2.58 ± 0.107 [a]
C: 65 + years	10	1.56 ± 0.218	5	1.24 ± 0.348 [b]	5	1.87 ± 0.208 [c]
All	30	1.37 ± 0.204	15	0.45 ± 0.188 [a]	15	2.29 ± 0.127 [a]

p= 0.05
a Statistically significant between public and private property.
b Statistically significant from all age classes of development within public property.
c Statistically significant from developments 35-64 years only within private property.

Table 14. Five most prevalent species, Grand Junction, CO, 2004.

Age Class A: 0-34 yrs.			Age Class B: 35-60 yrs.			Age Class C: 61 + yrs.		
Species	n	% pop.	Species	n	% pop.	Species	n	% pop.
Populus tremuloides	107	16%	*Fraxinus spp.*	100	14%	*Ulmus spp.*	211	24%
Fraxinus spp.	69	10%	*Populus tremuloides*	63	9%	*Ailanthus altissima*	137	15%
Malus spp.	50	7%	*Juniperus scopulorum*	55	8%	*Juniperus scopulorum*	88	10%
Juniperus scopulorum	43	6%	*Ulmus spp.*	45	6%	*Gleditsia triacanthos*	80	9%
Salix spp.	43	6%	*Salix spp.*	40	6%	*Fraxinus spp.*	65	7%
Total		46%	Total		42%	Total		65%

Species composition (Table 14) appears to be similar in both Age Classes A and B, with four out of five of the same species present in both groups. Though Age Class C has some species in common with that found in the younger age classes, it appears to be composed primarily of pioneer or weed species, such as ailanthus and Siberian elm.

Tree Size

Size of trees recorded in all three age classifications of neighborhood is presented in Table 15 showing comparisons among neighborhoods and also within neighborhoods, which yielded no significant differences. The forest population in each size class appears to be evenly distributed in each age class of neighborhood. Each size category also appears to have even representation throughout the age classes.

Size analysis was also performed based on ownership of property; either publicly managed or privately owned, and is presented in Table 16. While no significant differences were discovered when analyzed by age class, differences were apparent when analyzed by ownership of trees. The majority of saplings, 96%, were found on privately owned lands, leaving only 4% of all saplings under public management, which was found to be highly significant. The percentage of large trees on public property, 35% of all public trees, was also highly significant compared to only 13% of trees on private property. The proportion of medium trees on public property was also significantly higher, representing 28% of the public tree population, than that found on private property, only 16% of the private tree population.

Table 15. Chi-square test probabilities comparing size of trees in neighborhoods of varying age, Grand Junction, CO, 2004.

		Tree Size								
		n	< 4 in.	n	4 - 10 in.	n	11 - 16 in.	n	> 16 in.	Σ
Age of development	A: 0-34 years	108	0.42	146	6.81	48	1.60	38	2.77	340
	% trees in age class	32%		43%		14%		11%		25%
	% trees in size class	23%		31%		21%		19%		
	B: 35-64 years	111	7.04	142	0.11	86	2.94	83	7.33	422
	% trees in age class	26%		34%		20%		20%		31%
	% trees in size class	24%		30%		37%		41%		
	C: 65 + years	248	7.15	190	2.75	100	0.23	81	1.01	619
	% trees in age class	40%		31%		16%		13%		45%
	% trees in size class	53%		40%		43%		40%		
Σ		467		478		234		202		1381
		52%		53%		26%		22%		

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 8

Tree Condition

Condition of trees did not appear to vary greatly with age of neighborhood (Table 17). With the exception of the newest neighborhoods, Age Class A, no significant differences were found. Much like that found in the 1980 sample, the majority, 82%, of trees in these neighborhoods were assessed to be in excellent condition compared to 51% and 62% in Age Classes B and C, respectively. Frequency of trees in all other condition classes does not differ significantly.

More differences were noted in comparing public tree condition versus private tree condition, with poor and dead condition categories having no significant differences (Table 18). Public lands were found to have fewer trees in excellent condition, 28% of all publicly managed trees compared to 67% of all private trees, but more trees in good and fair condition categories. The majority, 96%, of all trees in excellent health were found on private lands. Forty-five percent of the public tree population was listed in good health compared to only 20% of private trees. Also significant, yet not as highly significant as good and excellent trees, are public trees in fair condition with 19% of public trees compared to only 8% of private trees. While a larger percentage of the public tree population was found in poor condition, 7% compared to 2% of the private forest component, this was not found to be significant.

Table 16. Chi-square test probabilities comparing size of trees on public and private property in Grand Junction, CO, 2004.

		Tree Size								
		n	< 4 in.	n	4 - 10 in.	n	11 - 16 in.	n	> 16 in.	Σ
Ownership	Private	450	1.19	452	0.48	201	0.81	161	3.09	1264
	% trees in owner. class	36%		36%		16%		13%		92%
	% trees in size class	96%		95%		86%		80%		
	Public	17	12.87***	26	5.19	33	8.76*	41	33.34***	117
	% trees in owner. class	15%		22%		28%		35%		8%
	% trees in size class	4%		5%		14%		20%		
Σ		467		478		234		202		1381
		34%		35%		17%		15%		

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 4

Table 17. Chi-square test probabilities comparing condition of trees in neighborhoods of varying age, Grand Junction, CO, 2004.

		Tree Condition										
		Excellent		Good		Fair		Poor		Dead		Σ
		n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square	
Age of development	A: 0-34 years	278	17.85 *	42	14.75	17	6.51	2	6.02	1	6.01	340
	% trees in age class	82%		12%		5%		1%		0%		25%
	% trees in cond. class	32%		14%		13%		5%		3%		
	B: 35-64 years	217	9.70	114	4.49	56	7.62	17	2.17	18	6.91	422
	% trees in age class	51%		27%		13%		4%		4%		31%
	% trees in cond. class	25%		37%		44%		44%		56%		
	C: 65 + years	382	0.31	150	1.20	54	0.15	20	0.36	13	0.13	619
	% trees in age class	62%		24%		9%		3%		2%		45%
	% trees in cond. class	44%		49%		43%		51%		41%		
Σ		877		306		127		39		32		1381
		64%		22%		9%		3%		2%		

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 8

Table 18. Chi-square test probabilities comparing condition of trees on public and private property in Grand Junction, CO, 2004.

		Tree Condition										
		Excellent		Good		Fair		Poor		Dead		Σ
		n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square	
Ownership	Private	844	2.13	253	2.62	105	1.09	31	0.62	31	0.10	1264
	% trees in owner. class	67%		20%		8%		2%		2%		92%
	% trees in cond. class	96%		83%		83%		79%		97%		
	Public	33	22.96 ***	53	28.28 ***	22	11.74 *	8	6.67	1	1.08	117
	% trees in owner. class	28%		45%		19%		7%		1%		8%
	% trees in cond. class	3%		17%		17%		21%		3%		
Σ		877		306		127		39		32		1381
		64%		22%		9%		3%		2%		

* p = 0.05
** p = 0.01
*** p = 0.005

Comparative Analysis within the City of Grand Junction, 1980-2004

Species diversity

While no differences were noted among the overall species diversity of the entire urban tree population in Grand Junction between 1980 (1.75 ± 0.215) and 2004 (1.37 ± 0.204), differences were found among public and private property and age classes of development (Table 19); nor was there change in overall diversity in all age classes.

Overall diversity of public street trees, inclusive of all age classes, was found to be significantly higher in 1980 (0.93 ± 0.154) than in 2004 (0.45 ± 0.188, Table 19). Diversity decreased significantly in all age classes except in Age Class C where diversity only decreased from 1.33 (± 0.085) to 1.24 (± 0.348) from 1980 to 2004, respectively. Diversity in Age Class A decreased from an average diversity index of 0.67 (± 0.378) to 0.10 (± 0.100) in 2004. Neighborhoods in Age Class B saw the highest decline decreasing from 0.78 (± 0.161) in 1980 to no trees in the sample area, hence no diversity (0.00 ± 0.000), in 2004.

Less change in species diversity was observed on private property (Table 19). Though overall private tree diversity decreased, the change was not statistically significant as was the case in both A and B class neighborhoods. However, neighborhoods in Age Class C saw a significant decrease in diversity from 2.46 (± 0.053) in 1980 to 1.87 (± 0.208) in 2004.

Table 19. Mean species diversity and standard of error comparison of urban forest from 1980 - 2004, Grand Junction, CO.

		Ownership					
		Overall		Public		Private	
	Age of neighborhood	# of blocks	$\bar{x} \pm \sigma$	# of blocks	$\bar{x} \pm \sigma$	# of blocks	$\bar{x} \pm \sigma$
1980	A: 0-10 years	6	1.64 ± 0.463	3	0.67 ± 0.378 [a]	3	2.61 ± 0.069
1980	B: 11-34 years	6	1.72 ± 0.429	3	0.78 ± 0.161 [a]	3	2.65 ± 0.149
1980	C: 35 + years	6	1.89 ± 0.257	3	1.33 ± 0.085	3	2.46 ± 0.053 [a]
1980	All	18	1.75 ± 0.215	9	0.93 ± 0.154 [a]	9	2.57 ± 0.058
		Ownership					
		Overall		Public		Private	
	Age of neighborhood	# of blocks	$\bar{x} \pm \sigma$	# of blocks	$\bar{x} \pm \sigma$	# of blocks	$\bar{x} \pm \sigma$
2004	A: 0-34 years	10	1.27 ± 0.404	5	0.10 ± 0.100 [a]	5	2.44 ± 0.206
2004	B: 35-60 years	10	1.29 ± 0.433	5	0.00 ± 0.000 [a]	5	2.58 ± 0.107
2004	C: 61 + years	10	1.56 ± 0.218	5	1.24 ± 0.348 [b]	5	1.87 ± 0.208 [ac]
2004	All	30	1.37 ± 0.204	15	0.45 ± 0.188 [a]	15	2.29 ± 0.127

a statistically significant between sample years

b statistically significant among age classes within the same sample year

c statistically significant from age class B only

$p = 0.05$

Tree Size

Chi-square analysis of public and private trees comparing size from 1980 to 2004 found the most variation occurred in private trees (Table 20). The percentage of saplings (under four inches diameter) was highly significant as it fell from 64% of the total private tree population to 36% in 2004. Small trees, those four to ten inches in diameter, increased significantly from 19% in 1980 to 36% of the total private tree population in 2004. Trees 11 – 16 inches in diameter also rose significantly from 7% in 1980 to 16% in 2004. No significant difference in the frequency of large trees was found on private property.

Though some change occurred among the frequency of size classes on public property, none were found to be significant. The largest change was found in large trees, those over 16 inches in diameter, which rose from 25% in 1980 to 35% in 2004.

Table 21 presents the chi-square values of frequency of trees in each size category in each age class of neighborhood, inclusive of all public and private trees. Comparing the sample years of 1980 and 2004, the most differences are noted in Age Class A. In 1980, 90% of all trees in Age Class A were saplings (> 4 in. diameter) compared to 32% in 2004. Because the majority of trees recorded in 1980 were in the smallest category, very few trees were found in larger sizes, and as the frequency of trees in each of those larger categories has increased, they were all found to be significantly higher than in 1980. Trees measuring four to ten inches in diameter accounted for only 9% of the population in Age Class A in 1980 whereas they were the majority of trees in this age class in 2004 (43% of trees). The populations of trees 11-16 inches in diameter and over 16 inches in

Table 20. Chi-square test probabilities comparing size of trees on public and private property from 1980-2004, Grand Junction, CO.

Privately-owned trees								
	< 4 in.		4 - 10 in.		11 - 16 in.		> 16 in.	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	478	50.74 ***	143	27.86 ***	54	17.67 ***	75	1.89
*% tree pop.^*	64%		19%		7%		10%	
2004	450	30.11 ***	452	16.53 ***	201	10.48 *	161	1.12
*% tree pop.^*	36%		36%		16%		13%	

DF= 3 ^ % of tree population during sample year

Publicly-managed trees								
	< 4 in.		4 - 10 in.		11 - 16 in.		> 16 in.	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	30	0.39	33	0.01	54	0.39	38	1.09
*% tree pop.^*	19%		21%		35%		25%	
2004	17	0.51	26	0.02	33	0.52	41	1.45
*% tree pop.^*	15%		22%		28%		35%	

DF= 3 ^ % of tree population during sample year

* significant at the .05 level
** significant at the .01 level
*** significant at the .005 level

diameter also rose significantly from 1980-2004. In 1980, only 1% and 0%, respectively, of the population in these age groups which increased to 14% and 11% giving the population a more even size dispersal.

Fewer changes were noted in Age Classes B and C. In middle-aged neighborhoods, the only significant difference identified was the frequency of trees under four inches in diameter, which decreased from 44% in 1980 to 26% in 2004. Other size classes increased slightly, creating a more even size distribution in the recent sample year. While saplings (trees under 4 inches diameter) decreased in Age Class B, their frequency grew, but not significantly, in Class C, rising from 29% to 40%. Trees sized 4-10 inches also increased (29% to 31%) though it was not significant. The only size class of trees in Age

Class C to change significantly were the largest trees, those over 16 inches in diameter, which fell from 26% of the population to 13%.

Table 21. Chi-square test probabilities comparing size of trees in neighborhoods of varying age from 1980-2004, Grand Junction, CO.

Age Class A: 0-34 years								
	< 4 in.		4 - 10 in.		11 - 16 in.		> 16 in.	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	298	47.31 ***	29	38.18 ***	4	18.31 ***	1	17.32 ***
*% tree pop.^*	90%		9%		1%		0%	
2004	108	46.20 ***	146	37.29 ***	48	17.88 ***	38	16.91 ***
*% tree pop.^*	32%		43%		14%		11%	

DF= 3

Age Class B: 35-64 years								
	< 4 in.		4 - 10 in.		11 - 16 in.		> 16 in.	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	132	9.26 *	69	4.12	59	0.04	42	1.97
*% tree pop.^*	44%		23%		20%		14%	
2004	111	6.63	142	2.94	86	0.03	83	1.41
*% tree pop.^*	26%		34%		20%		20%	

DF= 3

Age Class C: 65 + years								
	< 4 in.		4 - 10 in.		11 - 16 in.		> 16 in.	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	78	4.56	78	0.16	45	0.02	70	12.55 **
*% tree pop.^*	29%		29%		17%		26%	
2004	248	1.99	190	0.07	100	0.01	81	5.49
*% tree pop.^*	40%		31%		16%		13%	

DF= 3

* p = 0.05
** p = 0.01 level
*** p = 0.005 level
^ = % of tree population during sample year.

Tree Condition

Condition of trees was compared between the sample years for those trees found on public and private property (Table 22) and also for trees in each age class of development (Table 23).

Among trees on private property, the frequency of trees in excellent and good condition in these populations increased from 1980 to 2004, though not significantly. The only significant change was found in the frequency of private trees in poor condition which decreased from 8% to 2% of the population.

No significant changes in the condition of public trees were found. The public tree population experienced a decrease in the frequency of trees in excellent condition during the sample years though it was not statistically significant. The percentages of trees in good and fair conditions did increase from 21% in 1980 to 45% in 2004 and 13% in 1980 to 19% in 2004, respectively, though this was also not found to be significant.

No significant differences occurred in the condition of trees in Age Class A between 1980 through 2004 though some were observed in Age Classes B and C (Table 23). Although the percentage of the urban tree population reported in excellent and good conditions in Age Class B increased over this time span, they were not found to be significant. The only significant difference was observed in the percentage of trees found in poor condition, which decreased from 16% in 1980 to 4% in 2004.

The same trend was found in Age Class C with percentages of the tree population in excellent and good conditions increasing, though not significantly. The percentage of the tree population found in poor condition decreased significantly from 17% in 1980 to 3% in 2004. A significant difference was also found in the percentage of trees in fair condition, which decreased from 20% in 1980 to 9% in 2004.

Table 22. Chi-square test probabilities comparing change in tree condition on public and private property from 1980-2004, Grand Junction, CO.

Private Trees											
		Excellent		Good		Fair		Poor		Dead	
		n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square
Year	1980	463	1.16	121	2.40	84	2.63	57	17.91 ***	25	0.82
	% trees in sample year	62%		16%		11%		8%		3%	
	% trees in cond. class	35%		32%		44%		65%		45%	
	2004	844	0.69	253	1.42	105	1.56	31	10.63 *	31	0.49
	% trees in sample year	67%		20%		8%		2%		2%	
	% trees in cond. class	65%		68%		56%		35%		55%	

DF=4

Public Trees											
		Excellent		Good		Fair		Poor		Dead	
		n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square
Year	1980	50	0.15	33	5.23	20	0.65	42	6.40	10	2.22
	% trees in sample year	32%		21%		13%		27%		6%	
	% trees in cond. class	60%		38%		48%		84%		91%	
	2004	33	0.20	53	6.93	22	0.86	8	8.48	1	2.94
	% trees in sample year	28%		45%		19%		7%		1%	
	% trees in cond. class	40%		62%		52%		16%		9%	

DF=4

* p = 0.05
** p = 0.01
*** p = 0.005

Table 23. Chi-square test probabilities comparing condition of trees in neighborhoods of varying age from 1980-2004, Grand Junction, CO.

Age Class A: 0-34 years										
	Excellent		Good		Fair		Poor		Dead	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	257	0.2	45	0.09	15	0.04	7	1.47	8	2.84
*% tree pop.^*	77%		14%		5%		2%		2%	
2004	278	0.2	42	0.09	17	0.04	2	1.43	1	2.77
*% tree pop.^*	82%		12%		5%		1%		0%	

DF= 4

Age Class B : 35-64 years										
	Excellent		Good		Fair		Poor		Dead	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	138	0.69	66	1.1	36	0.15	47	15.44***	15	0.11
*% tree pop.^*	46%		22%		12%		16%		5%	
2004	217	0.49	114	0.79	56	0.11	17	11.05*	18	0.08
*% tree pop.^*	51%		27%		13%		4%		4%	

DF= 4

Age Class C: 65 + years										
	Excellent		Good		Fair		Poor		Dead	
	n	chi-square	n	chi-square	n	chi-square	n	chi-square	n	chi-square
1980	118	7.7	43	4.23	53	12.8*	45	32.11***	12	2.53
*% tree pop.^*	44%		16%		20%		17%		4%	
2004	382	3.37	150	1.85	54	5.6	20	14.06**	13	1.11
*% tree pop.^*	62%		24%		9%		3%		2%	

DF= 4

* p = 0.05
** p = 0.01
*** p = 0.005
^ % of tree population during sample year

Residents' Attitude Survey, Grand Junction, 2004

Response rate and demographic characteristics

Though the sample size of residents surveyed in Grand Junction was small and limited to the neighborhood blocks inventoried, the response rate was good overall, especially in Age Classes A and C (Table 24). Overall, 43.75% or surveys mailed were returned. Within the neighborhoods, the highest return rate was observed in Age Class A (57.14%) while Age Class B had the lowest rate (33.96%). Of the responses received, 34.29% were from residents in Age Class A and 40% were from Age Class C. The least responses were received from residents in Age Class B which made up only 25.71% of the surveys received.

Table 24. Survey response rate in selected age classes of neighborhood throughout Grand Junction, CO, 2004.

Age class of neighborhood	Sent	Rec'd	Return Rate	% Response received
A: 0-34 years	42	24	57.14%	34.29%
B: 35-64 years	53	18	33.96%	25.71%
C: 65 + years	65	28	43.08%	40.00%
Overall	160	70	43.75%	100.00%

The majority of respondents, 56.92%, were female while only 43.08% were male (Table 25). Most were homeowners (86.57%) and were also over the age of 60 (38.24%). Approximately 71% had a completed an Associate's degree or higher level of college education. Less than 2% had completed less than a high school education. Levels of income were rated

Table 25. Socio-demographic characteristics of survey respondents, Grand Junction, CO, 2004.

Characteristic	n	%
Gender		
Male	28	43.08%
Female	37	56.92%
	65*	100.00%
Age		
18-25 years	6	8.82%
26-35 years	13	19.12%
36-45 years	8	11.76%
46-60 years	15	22.06%
60+ years	26	38.24%
	68*	100.00%
Ownership		
Own	58	86.57%
Rent	9	13.43%
	67*	100.00%

Characteristic	n	%
Education		
Grade school	1	1.52%
High school	18	27.27%
Associates	19	28.79%
Bachelors	21	31.82%
Masters/ PhD	7	10.61%
	66*	100.00%
Income/month		
< $2000	17	27.87%
$2001 - $3000	16	26.23%
$3001 - $4000	9	14.75%
$4001 - $5000	8	13.11%
> $5000	11	18.03%
	61*	100.00%

* Though sixty-eight surveys were returned, some were incomplete. Some did not choose to respond to gender, ownership of home, education, and income.

in increments with most, 27.87% and 26.23%, earning less than $2,000 and between $2,001 and $3,000, respectively, each month.

Urban street tree benefits (survey question 1)

Residents were asked to rate the degree of benefit received for fourteen statements of positive features of trees listed below:

1a.	provides shade;	1h.	slows wind speed;
1b.	pleasing to the eye;	1i.	increases privacy ;
1c.	flowers on trees;	1j.	filters dust from air;
1d.	autumn color;	1k.	increases property value;
1e.	neighborhood more livable;	1l.	bring nature close;
1f.	reduce noise;	1m.	attract birds and wildlife;
1g.	cools building in summer;	1n.	gives sense of pride.

For each neighborhood, mean benefit ratings (rated on a scale of 1 to 5 with 1 being the least benefit and 5 the most benefit) are given in Table 26. Overall, residents rated the aesthetic statements; pleasing to the eye ($\bar{x}$= 4.33), autumn color ($\bar{x}$= 4.22), and neighborhood more livable ($\bar{x}$= 4.16) as providing the most benefit. Some of the functional benefits of trees; slows wind speed ($\bar{x}$= 3.32), reduces noise ($\bar{x}$= 3.36), and filters dust from the air ($\bar{x}$= 3.33) received the lowest ratings.

Ratings did not vary considerably among the neighborhoods though some patterns were found. In all but two of the statements, ratings in Age Class C were higher than given in the other two neighborhoods ($\bar{x}$= 3.95, all statements). The average rating for all statements given in question 1 in Age Class A was the lowest (3.59).

Table 26. Residents' mean ratings* and ranking of benefits received from the positive features of urban street trees in selected neighborhoods, Grand Junction, CO, 2004.

Survey statement		Overall			A: 0-34 years			B: 35-64 years			C: 65 + years		
		rank	mean	n	rank	mean	n	rank	mean	n	rank	mean	n
1b	Pleasing to eye	1	4.33	69	1	4.04	23	2	4.33	18	1	4.57	28
1d	Autumn color	2	4.22	68	3	3.87	23	1	4.35	17	2	4.43	28
1e	Neighborhood more livable	3	4.16	69	2	3.96	23	3	4.11	18	3	4.36	28
1l	Brings nature close	4	4.00	67	6	3.70	23	5	3.94	16	4	4.29	28
1a	Provides shade	5	3.99	69	5	3.74	23	9	3.72	18	3	4.36	28
1m	Attracts birds/wildlife	6	3.91	69	4	3.78	23	7	3.83	18	6	4.07	28
1n	Gives sense of pride	6	3.91	68	7	3.61	23	4	4.00	17	5	4.11	28
1g	Cools buildings in summer	7	3.85	68	4	3.78	23	6	3.88	17	7	3.89	28
1k	Increases property value	8	3.77	69	8	3.57	23	7	3.83	18	7	3.89	28
1i	Increases privacy	9	3.62	68	9	3.43	23	8	3.76	17	8	3.68	28
1f	Reduce noise	10	3.36	69	10	3.34	23	11	3.31	18	11	3.39	28
1c	Flowers on trees	11	3.33	66	12	3.05	22	10	3.47	17	9	3.48	27
1j	Filters dust from air	11	3.33	66	12	3.05	21	10	3.47	17	10	3.46	28
1h	Slows wind speed	12	3.32	66	11	3.30	23	12	3.27	16	12	3.37	27

*Means are based on statements rated on a scale from 1 (no benefit) to 5 (most benefit) for all characteristics.

Urban street tree annoyances (survey question 3)

Similar to the format presented in question one, residents were asked to rate the degree of annoyance received from negative features of street trees. Negative features included:

3a. sidewalks damaged;
3b. insects/disease in trees;
3c. break power lines in storms;
3d. suckers grow at base;
3e. fruit or seeds fall;
3f. flower parts fall;
3g. leaves fall in autumn;
3h. falling branches;
3i. darkens street at night;
3j. causes allergies;
3k. limited visibility reduces security;
3l. blocks sun in winter;
3m. branches block line of sight;
3n. roots clog sewers.

Overall, residents in Grand Junction rated insects and disease ($\bar{x}$= 2.51) as the most annoying negative feature of street trees (Table 27). Other features receiving high annoyance ratings were: roots clog sewer ($\bar{x}$= 2.39), fruits or seeds that fall ($\bar{x}$= 2.35), and falling branches ($\bar{x}$= 2.24). Residents in Age Classes A and C were most annoyed by insects and disease in trees ($\bar{x}$=2.70, $\bar{x}$= 2.57, respectively). Those living in Age Class B found falling fruit/seeds to be the most annoying feature ($\bar{x}$= 2.59).

Opinion of tree condition (survey question 5)

Residents in all age classes rated the street trees in their neighborhoods in good to very good condition ($\bar{x}$= 3.63, Table 28). The mean rating of condition in each class ranged from 3.58 (Age Class A) to 3.68 with residents of Age Class C giving their street tree the highest rating. Little variation was found in the mean condition ratings between neighborhoods.

Table 27. Residents' mean ratings* and ranking of annoyance of negative features of urban street trees in selected neighborhoods, Grand Junction, CO, 2004.

Survey statement		Overall			A: 0-34 years			B: 35-64 years			C: 65 + years		
		rank	mean	n	rank	mean	n	rank	mean	n	rank	mean	n
3b	Insects/disease on trees	1	2.51	68	1	2.70	23	3	2.18	17	1	2.57	28
3n	Roots clog sewer	2	2.39	67	3	2.41	22	2	2.35	17	3	2.39	28
3e	Fruit or seeds fall	3	2.35	66	4	2.38	21	1	2.59	17	4	2.18	28
3h	Falling branches	4	2.24	66	6	2.18	22	4	2.00	17	2	2.44	27
3c	Break power lines in storm	5	2.08	66	7	1.91	22	9	1.44	16	1	2.57	28
3g	Falling leaves in autumn	6	2.06	68	5	2.30	23	4	2.00	17	6	1.89	28
3j	Causes allergies	7	1.99	67	2	2.45	22	7	1.59	17	7	1.86	28
3d	Suckers grow around base	8	1.93	67	6	2.05	22	5	1.88	17	7	1.86	28
3a	Sidewalks damaged	9	1.90	67	7	1.91	22	6	1.71	17	5	2.00	28
3f	Flower parts fall	10	1.62	66	8	1.90	21	10	1.41	17	8	1.54	28
3k	Limited visibility and security	11	1.54	67	9	1.73	22	10	1.41	17	10	1.46	28
3m	Blocks line of sight	12	1.49	67	10	1.59	22	8	1.47	17	11	1.43	28
3l	Blocks sun in winter	13	1.46	67	11	1.55	22	11	1.29	17	9	1.50	28
3i	Darkens street at night	14	1.42	67	10	1.59	22	12	1.17	17	11	1.43	28

*Means are based on statements rated on a scale from 1 (not an annoyance) to 5 (very great annoyance) for all characteristics.

Table 28. Residents' mean condition ratings* of street trees in selected neighborhoods, Grand Junction, CO, 2004.

Age Class of neighborhood	n	$\bar{x}$
A: 0-34 years	24	3.58
B: 35-64 years	18	3.61
C: 65 + years	28	3.68
Overall	70	3.63

*Means are based on resident ratings on a scale from 1 (very poor) to 5 (excellent).

Size of street trees (survey question 6)

As depicted in Table 29, residents in Age Class C rated the size of their street trees to be slightly less than desirable ($\bar{x}$= 1.96). As a rating of 2.0 was considered to be 'just right', residents in Age Class A were also not satisfied with the size of trees in their neighborhood ($\bar{x}$= 2.58).

Table 29. Residents' mean size ratings* of street trees in selected neighborhoods, Grand Junction, CO, 2004.

Age Class of neighborhood	n	$\bar{x}$
A: 0-34 years	24	2.58
B: 35-64 years	18	2.50
C: 65 + years	28	1.96
Overall	70	2.38

*Means are based on resident ratings on a scale from 1 (too small) to 3 (too large).

Pruning and city maintenance of street trees (survey questions 7 and 9)

Residents in Grand Junction judged the pruning of their street trees to be satisfactory with a mean overall rating of 3.14 (Table 30). This assessment did not vary with neighborhood age. The lowest rating was found in Age Class C ($\bar{x}$ = 2.92) and the highest in Age Class B ($\bar{x}$ = 3.31). Maintenance of street trees was rated slightly higher overall and in all neighborhoods ($\bar{x}$ = 3.28, overall) than ratings of city pruning (Table 31).

Table 30. Residents' mean pruning ratings* of street trees in selected neighborhoods, Grand Junction, CO, 2004.

Age Class of neighborhood	n	$\bar{x}$
A: 0-34 years	22	3.05
B: 35-64 years	16	3.31
C: 65 + years	26	2.92
Overall	64	3.14

*Means are based on resident ratings on a scale from 1 (very poor) to 5 (excellent).

Table 31. Residents' mean rating of city maintenance* of street trees, Grand Junction, CO, 2004.

Age class of neighborhood	n	$\bar{x}$
A: 0-34 years	22	3.09
B: 35-64 years	16	3.44
C: 65 + years	26	3.12
Overall	64	3.28

*Means are based on resident ratings on a scale from 1 (very poor) to 5 (excellent).

Tree plantings (Question 10)

Most residents in each neighborhood believed more trees should be planted along streets in Grand Junction (Table 32). The overall percentage of respondents favoring more trees was 82.26% compared to only 17.74% of residents that did not support more trees. The highest proportion of residents in favor of planting more trees was found in Age Class C (88.46%) while the lowest was found in Age Class A (72.73%). Though the majority of residents agreed trees were important for the community, the highest percentage of residents opposed to increasing urban tree plantings was found in Age

Class A (27.27%) compared to only 14.29% and 11.54% in Age Class B and C, respectively.

Table 32. Residents' opinions on increasing urban tree plantings, Grand Junction, Co, 2004.

	All	Yes		No	
Age class of neighborhood	n	n	%	No	%
A: 0-34 years	22	16	72.73%	6	27.27%
B: 35-64 years	14	12	85.71%	2	14.29%
C: 65 + years	26	23	88.46%	3	11.54%
Overall	62	51	82.26%	11	17.74%

DISCUSSION

The City of Grand Junction, CO

Comparative analysis of the complete urban forest, inclusive of all public and private trees, revealed several key differences between the two components, as indicated in both 1980 and 2004. Similarly, by stratifying the city's developments by age, other differences were noted about each area's urban forest which can aid urban managers in caring for and improving the urban forest.

Overall, in the city of Grand Junction, privately-owned trees were found to be more diverse than the publicly-owned trees. This may come as no surprise, considering that many public urban forest managers limit the variety of trees to be planted in public space due to budgeting restrictions, maintenance factors, pests/disease/annoyance factors, and public preference. Public forests are commonly composed of a few select species that: a.) perform well under urban stresses with minimal maintenance; b.) are desired for some aesthetic attribute; and c.) perhaps less likely to be damaged during periodic adverse weather conditions.

This was evident in both sample years of 1980 and 2004 with some differences found within the 2004 sample. Overall species diversity on publicly-owned land, which included all age classes of neighborhoods, was significantly lower than overall private species diversity. However, when analyzed by age of neighborhood, this trend was found in both Age Class A and B, but not in Age Class C, where no difference occurred between public and private tree diversity. This may be attributed to the lack of public street trees in Age Class B and the reduced number in Age Class A in comparison to Age Class C. Public diversity in Age Class C was also significantly higher than the public diversity in Age Class A and B in 2004. This suggests that, though fewer public trees were found in these areas, diversity and planting of street trees in neighborhoods has not been a priority in more recent times. Recent developments, often designed in a curvilinear fashion and lacking traditional sidewalks, differ in style from those of older, more-established neighborhoods that are commonly arranged in a traditional grid pattern that promotes walkability and usually have sidewalks and treelawns. In the absence of a sidewalk and treelawn, many developers leave out street trees as part of the development plan, which seemingly are not required by a municipal policy. Additionally, with development spreading farther from the city's core, economic strain is added to public services departments which now must incur the increased cost of providing water, sewage, and other municipal services to the outskirts, possibly resulting in less funding available for street trees. In fact, less revenue is collected from residential land than is typically spent on services to these homes (Macie 1998). Contrarily, considerably less money is spent to service agricultural and rural land than collected in revenue (Macie 1998).

This trend was not affected by age of neighborhood in 1980, as diversity was consistently higher on private property than on public property in all three age classes. No differences were noted between the age classes, indicating that no difference in management and planting patterns existed between public and private properties in each neighborhood. However, age of neighborhood did influence size distribution of the overall urban forest during the 1980 sampling, while the sizes of urban trees did not differ among neighborhoods in 2004. In 1980, newer developments, established within the previous decade had a significantly higher proportion of saplings in comparison to the two older neighborhood classifications. These areas also had significantly fewer medium and large-sized trees. In the same manner, middle-aged neighborhoods, built between 11-40 years prior, had a significantly higher percentage of medium-sized trees, while the oldest areas, those built over 60 years prior, had a higher percentage of large trees. These patterns reflect upon development practices and the need for stricter tree preservation measures. Because it may seem advantageous for some developers to remove any and all vegetation prior to development and begin with a 'clean slate' that will permit easy access of large equipment and allow new homeowners to design their own landscape, most trees in recent developments were established as young trees after building. As the entire community benefits from trees established on all private properties, this suggests the need for tree preservation ordinances and more collaboration between city zoning and development officials and private developers as part of the public good.

Public and private ownership also affected size distribution of trees. Owing to the restrictions imposed on public urban tree plantings, managers are not only limited with the variety of species available to plant but also must adhere to size limitations that allow only trees of a certain potential size to be planted in public areas. These trees are subjected to more human contact, urban environmental limitations, and less individualized care. Consequently, establishment of small trees and saplings is not practical. Public urban trees are also selected by species for desirable characteristics such as durability, adaptation to urban stresses, and a reduced amount of seeds or suckers produced, among other features. Several of the species found on private property were those that could be classified as prolific seeders or pioneer species, such as Siberian elm and ailanthus, which are considered by many professionals to be weed trees and are commonly restricted from planting by public managers. This was apparent in the distribution of tree sizes in both sample years on public and private property. In 1980, an overwhelming majority of saplings (less than four inches diameter) were found on private property while significantly more medium (diameter of 11-16 inches) and large-sized trees (over 16 inches diameter) were located on public property. Similarly, during the 2004 sample, the public forest composition held a significantly lower percentage of saplings and a higher percentage of large trees than did the private sector. This could be attributed to the preference of larger trees lining boulevards and the financial incentive cities have to select trees that will attain a larger size, higher survivorship, and, consequently have a longer lifespan and more contribution to the city. Additionally, private land can change ownership several times, while during the same period public property will remain a public good. Thus, private land managers with varying objectives are more likely to manage and alter the vegetation on their property.

Of the trees located on private property in 1980, they were also found to be in better health, as indicated by the percentage of trees found in the various condition classes, than those under public management. Significantly more trees on public property were found in poor condition and significantly fewer trees in excellent condition than on private property, suggesting that ownership or location of trees can influence maintenance, care, and, consequently, tree health. Generally, trees planted on private property are cared for by the homeowner, whereas a small division of public management within the city is charged with the care of the entire public urban forest population. Although the population of trees in the public component is less than that in the private component, individual care from the time of deliberate planting can lead to improved tree health and condition of the entire urban forest. Additionally, publicly-owned trees are neither the direct property nor responsibility of a single individual and are not guarded by any one party in the same manner that private homeowners may provide. Thus, destructive behavior towards the public good is not a serious concern of many homeowners and may not be reported to city managers.

Condition trends were similar in the 2004 sampling. Even though significantly fewer trees in excellent condition were found on public property, the percentages of public trees reported in both good and fair condition were significantly higher than found on private property, indicating that the public forest management has consistently maintained tree condition, and that the overall condition of managed trees can be considered good. These values could indicate that forest managers are doing a better job overall on care and maintenance of urban trees as well as selecting more appropriate species. An additional factor could also be the reduction in the American elm population along streets since 1980. The original 1980 sampling was intended to determine the effects of Dutch elm disease (DED) nationwide, which had begun to affect elm trees in Grand Junction, the western-most city included in the study at that time. In the time since DED, the municipal forestry department has been removing diseased elms that were once very prevalent on city streets, thereby removing some of the trees that may have been assessed in poor condition in 1980.

Within neighborhoods, trees in the most recent developments (Age Class A) were found to be in better condition than in other neighborhoods in both sample years. These areas exhibited significantly more trees in excellent condition and fewer trees in poor condition in 1980. In 2004, significantly more trees in excellent condition were found in the same age class, though there were no differences in the frequencies of poor and dead trees like that found in 1980. As more young trees, as indicated by size, were also found in younger neighborhoods the better health of the population could be attributed to the fairly young population of trees that have been less exposed to urban conditions. Additionally, because the trees on the privately owned sector comprise the majority of trees in each age class, this effect could likely be attributed to individual property owner care. Saplings in newer developments are likely to be those purposefully planted with the monetary and physical input from the landowner, and thus guarded and cared for. No difference in condition was found in Age Class B and Age Class C suggesting that as these plantings and volunteers age, care does not differ between the neighborhoods.

Grand Junction after 24 years

Urban forest managers often have very little historical information of population dynamics and change to guide their practices and to assist in outreach and technical problems with residents (Kielbaso et al 1993). Using the data collected in 1980 as a base point, changes in species diversity, tree size, and tree condition were identified for a 24-year duration until 2004.

The overall species diversity index of the entire urban forest population remained unchanged after 24 years, giving the appearance that urban managers and residents maintained urban forest diversity. However, through analysis of varying neighborhoods and ownership, it is clear that this is not the case. Though no differences in overall species diversity were noted from 1980-2004 among the age classes (diversity did decline though the change was not significant), that was not the case on public versus private property. Overall public forest diversity decreased markedly from 1980 to 2004, mostly attributed to diversity decline occurring in the youngest (Age Class A) and middle-aged neighborhoods (Age Class B). This could possibly coincide with a decrease in funding and plantings and an increase in street tree removals as indicated by another urban forest survey conducted in 1989 (Hoefer). No difference was found in the public species diversity in the oldest neighborhoods suggesting that species diversity has not been of prime importance in recent years.

In respect to changes in tree size structure, publicly owned tree size distribution remained unchanged, indicating the city has been consistent with plantings and removals in the last

24 years. Though this does not mean that the city has been maintaining an adequate stock of urban trees, rather, it implies that they have maintained earlier stocking levels which were found to be largely under-stocked (Hoefer 1989).

While low stocking levels remained in the public sector, many changes were observed in the private sector, which infer that tree plantings on private property have declined over the years. The percentage of the private tree population identified as saplings decreased significantly while increasing in the next two larger categories, suggesting that as these trees grow and advance to the subsequent size cohort, creating an increase in the following size class, more saplings are not being planted to replace those that have grown into these next size classes.

Through analysis of change among age classes of neighborhood, it is apparent that much of this trend can be attributed to activities in the youngest development, Age Class A. Much like the pattern described above, the percentage of saplings decreased significantly in this age class while significant increases were observed in all other size classes, including larger trees. This could indicate that as new developments and subdivisions are added to the community, the value of planting and preserving trees has been overlooked. While increases in small, medium, and large-sized trees have occurred, implying the progression of size as trees mature, the frequency of saplings decreased, suggesting a decline in new plantings. The only additional temporal change noted was found in Age Class C where the presence of large trees decreased significantly, suggesting a higher mortality rate among some of the oldest trees that may have succumbed to Dutch elm disease or to old age.

Less noticeable changes occurred in tree condition. Percentages of publicly managed trees in all condition categories remained constant, indicating that city managers have maintained the level of health in the street tree population. Though the frequencies of trees in all condition classes have not changed, it may indicate that urban forest management, while maintaining the care given to street trees, has not sufficiently cared for trees to improve condition. Residents indicated a general disdain for urban forest management practices at the time of the initial survey, and decline, due partly to disease and insects, was noted among many of the cities street trees (Cannon 1980; Denison and Winegardner 1980).

The same was found in analysis among neighborhood age. No change was seen in the condition of trees in the newest developments while the percentage of trees in poor condition in both Age Classes B and C declined significantly, possibly indicating that residents are planting more species adapted to local conditions. Remarks found in the original sample data sheets from 1980 alluded to a trend among non-native homeowners (primarily from eastern states) to plant species native to their original homes, as they were more familiar and usually desirable for fall color (Cannon 1980). This was not markedly evident in the 2004 sampling as fewer non-native species were observed.

Resident survey, Grand Junction, 2004

Awareness of the physically apparent positive features of street trees, such as fall color and pleasing to the eye, appears to be more important than some of the functional benefits of trees, for example noise reduction and reducing wind speed. Residents in all neighborhoods consistently rated the more visibly apparent features as providing more benefit than the functional features, suggesting that they may not be aware that trees provide these services.

Of the annoying features, residents consistently rated problematic roots and insects/disease as the most annoying features of trees. One possible explanation could be that the species commonly found in abundance in urban lots (Siberian elm, silver maple) tend to have extensive root systems that often conflict with sewer systems. However, these problems are more recognizable to residents who, therefore, are more aware these annoyances exist. Because the city experienced Dutch elm disease more recently than the eastern portion of the country and the city had also been affected by lilac borers, locals may be more aware of the effects the disease had on their street tree population. Disease is clearly evident to residents while some may not make a connection between some indirect features, such as 'blocks sun and line of sight' or 'darkens streets at night', and urban trees.

Ratings of annoyance were generally low among all potentially negative features of street trees. Residents seem to view trees as a positive feature of their community and overwhelmingly agreed, in all neighborhoods, that urban street tree plantings should be increased.

Opinions on tree size and condition did not vary among neighborhoods. Residents in all neighborhoods rated their street trees in good to very good condition implying they are satisfied with urban forest care. Little variation was also found in size ratings though residents in newer developments (Age Classes A and B) rated their trees as slightly too large, those in the oldest developments (Age Class C), and highest percentage of large street trees (Table 21), rated size as satisfactory.

Many residents appeared indifferent when asked opinions on city maintenance of urban trees and pruning. Though most of the population was found to be in good condition (Table 23) , which may be due to city maintenance, most responses rated the overall maintenance and pruning as 'good' with very little variation among neighborhoods. This could likely be the case that trees in Grand Junction are generally well cared for and pruned, though it is uncertain to what degree residents are educated on proper pruning and maintenance.

Summary

• *What are the differences in species diversity, condition, and size of urban trees in neighborhoods of varying age?*

1.) Species diversity may be influenced by the age of neighborhood development as indicated by the 2004 sampling. This could be accounted for by development trends and residential preferences that change over time.

2.) The age of a neighborhood does affect the size structure of the urban forest as more smaller trees are found in areas most recently developed while the size of trees seems to increase according to age of development. This supports the idea of increased tree preservation, if present, at the time of construction to preserve trees of varying age.

3.) Trees appear to be in better health in newer developments, likely resulting from the higher frequency of saplings or younger trees.

• *What are the differences in species diversity, condition, and size of urban trees on public and private property?*

1.) Species diversity significantly increases under private ownership due in part to the better growing environment and care these trees receive and, consequently, the fact that private landowners are able to select species that public managers may be restricted from planting.

2.) Public species diversity may be higher, as found in 2004 and not in 1980, in older neighborhoods due to trends in urban plantings.

3.) Because planting smaller, more vulnerable trees on public rights-of-way is not a practical practice, saplings are more likely to be found under private ownership than public.

4.) Trees are consistently more likely to be in excellent condition when located on private grounds. Though trees in the 2004 sample were not found to be in mostly poor condition on public property (many were rated in good or fair condition), more trees in excellent condition were found on private property in both sample years.

• *How do species diversity, condition, and size of urban trees change over time?*

1.) Species diversity on public rights-of-way has declined considerably while no change in private diversity occurred.

2.) The presence of saplings has significantly decreased on private property and in the newest neighborhoods (Age Class A), possibly indicating a reduction in tree plantings by private homeowners, particularly those in newer subdivisions.

3.) Urban tree size distribution has remained unchanged on public property.

4.) Urban tree condition has remained unchanged on public property.

5.) Condition of trees on private lands has improved and may be due to an increased awareness of planting more climate appropriate species.

• *Does the age of neighborhood and characteristics of the urban tree population influence the attitudes of residents towards street trees?*

• *What are the opinions of residents in Grand Junction towards street trees?*

1.) Though the sample size and return rate were not high enough to allow statistical analysis, some trends were apparent. Most notably, residents did not seem to have a clear understanding of many of the positive features trees provide urban residents and the potential hazards (negative features).

2.) Neighborhood of residence had little or no effect on the attitudes towards urban tree size, condition, maintenance, and pruning in Grand Junction.

3.) Residents in all neighborhoods were generally postive about trees, rating the benefits received as higher than degree of annoyances received, and agreed more trees should be planted in public right-of-ways.

Recommendations

1.) Increasing species diversity on public property should be a paramount concern of urban managers, particularly in newer developments while at least maintaining existing diversity in older areas.

2.) Policies should be set that encourage more planting in new developments and tree preservation during construction. Urban managers should work toward increasing green cover in all areas, but particularly in locations of most recent development.

3.) More funding should be secured for better care of public urban trees. While overall urban tree condition was good, trees on privately-owned land were found to be in better condition, indicating that some improvement could be achieved.

4.) Programs to educate residents on the social, economic, and environmental benefits of urban trees would be beneficial to the entire urban forest. More awareness of the benefits of trees would encourage their planting in newer neighborhoods and provide support for preservation measures while helping residents to better understand the value of a diverse urban forest. Also, because the area has experienced increased growth in recent years, increasing awareness of native species would be beneficial to persons not native to Western Colorado.

5.) Engage residents in street tree plantings utilizing the enthusiasm and support for increasing the urban tree population. This will also serve to increase awareness of the benefits of urban trees and also provide an example of proper tree planting and species selection that residents may replicate on private property.

APPENDICES

APPENDIX A

Grand Junction compared to 10 cities, 1980

The city of Grand Junction was among ten cities selected across the U.S. to study the effects of ownership, whether public or private, and age of development in 1980 by U.S. Forest Service researchers. The following analysis compares the city of Grand Junction, Colorado to the nine other geographically dispersed cities based on their data. Though it was never published, this study provides important comparative data of urban forests across the nation, as well as a basis for the current 1980 to 2004 comparison of conditions in Grand Junction, CO.

1980

The city of Grand Junction was compared to the nine other cities included in the 1980 sampling to compare urban forest conditions. Since each city is representative of a unique geographical condition, the information should not imply that Grand Junction is similar to other cities in different eco-regions. Instead, it should serve solely for informative purposes to identify the state of the urban forest in Grand Junction as compared to other cities nationwide. Species diversity indices were calculated for each city's private and public forest populations and also calculated for each age classification of neighborhood. Condition and size of public and private trees in each age class of development are also compared.

Species Diversity

Analysis of overall species diversity in each city, inclusive of all age classes and public and private trees, found no difference in diversity indices between the ten sample cities (Table 33). Though there are no differences in collective urban forest diversity among sample cities, differences were noted once the overall forest was analyzed separately by the public and private components.

Publicly-owned and privately-owned components of the urban forest were compared among cities. Analysis of overall species diversity (both public and private and all age classes) in each city indicated no differences, while analysis by tree ownership (public or private) indicated a few differences among sample cities as listed in Table 33. The diversity index of the private component of Grand Junction's urban forest, ranked as having the seventh highest diversity index, was found to be no different than that in the nine other sample cities. However, differences were noted among the nine additional sample cities. All cities in the state of Ohio; Wooster (ranked second), Delaware (ranked fourth), Bucyrus (ranked third), and Bowling Green (ranked first); were significantly different from the privately owned urban forests of Jamestown, New York (ranked tenth). In addition to Jamestown, private species diversity in Bowling Green was significantly different from Charlottesville, Virginia (ranked sixth in private diversity), Hutchinson,

Table 33. Mean species diversity and standard error calculated using Tukey-Kramer on public and privately managed lands in 10 U.S. cities, 1980.

	Management								
	Private			Public			Overall		
City	$\bar{x}$	σ	diff.*	$\bar{x}$	σ	diff.*	$\bar{x}$	σ	diff.*
Bowling Green, OH	3.05	0.11	A	1.71	0.22	A	2.38	0.20	A
diversity rank	1			1			1		
Bucyrus, OH	2.80	0.09	AB	0.97	0.21	ABC	1.89	0.25	A
diversity rank	3			4			3		
Charlottesville, VA	2.60	0.14	BC	0.07	0.07	D	1.34	0.30	A
diversity rank	6			10			10		
Delaware, OH	2.80	0.14	AB	0.91	0.24	ABCD	1.86	0.27	A
diversity rank	4			6			5		
Grand Junction, CO	2.59	0.06	ABC	0.92	0.15	ABC	1.76	0.22	A
diversity rank	7			5			6		
Hutchinson, MN	2.56	0.08	BC	1.21	0.12	AB	1.88	0.16	A
diversity rank	8			2			4		
Jamestown, NY	2.25	0.10	C	0.77	0.16	AB	1.51	0.20	A
diversity rank	10			8			8		
Lincoln, NE	2.67	0.06	ABC	0.80	0.26	BCD	1.75	0.26	A
diversity rank	5			7			7		
W. Springfield, MA	2.48	0.10	BC	0.37	0.15	CD	1.42	0.27	A
diversity rank	9			9			9		
Wooster, OH	2.93	0.07	AB	1.03	0.22	ABC	1.98	0.26	A
diversity rank	2			3			2		

$p = .05$

******Cities with identical letters listed in 'difference' column are similar while those cities not connected by the same letter are significantly different.*

Minnesota (ranked eighth in private diversity), and Springfield, Massachusetts (ranked ninth in private diversity).

Analysis of public tree diversity, inclusive of all age classes found that Grand Junction is similar to all sample cities with the exception of Charlottesville, Virginia, which ranked as having the lowest diversity among the ten cities (Table 33). Among the ten sample cities, Grand Junction ranked as having the fifth highest diversity. Though it ranked as having median diversity, public tree diversity in Grand Junction was only significantly higher than that found in Charlottesville. Diversity in Charlottesville was also significantly lower than that in Bucyrus (ranked fourth), Wooster (ranked third), Bowling Green (ranked first), and Hutchinson (ranked second). However, the small sample size of public tree species in Charlottesville in comparison to all other cities should also be considered as a factor. Again, cities in Ohio ranked as those with the highest diversity indices.

Condition

Condition ratings for all trees, public and private, and inclusive of all age classes of development, were compared and are presented in Table 34. In comparison to the nine other sample cities in 1980, overall condition of the urban forest, inclusive of all public and private property and all age classes, in the city of Grand Junction differs significantly in the frequency of trees reported in both excellent and poor condition. With only 57% of trees in the city in excellent condition, the frequency of trees in this category are significantly lower than all other study cities with the exception of Hutchinson which reported only 55% of its total trees in excellent condition. Trees reported in poor

Table 34. Chi-square test probabilities comparing overall condition of all trees (public and private) in ten U.S. cities in all age developments, 1980.

City	Excellent n	Excellent Chi Square	Good n	Good Chi Square	Fair n	Fair Chi Square	Poor n	Poor Chi Square	Dead n	Dead Chi Square	Total
Bowling Green, OH	1864	6.55	165	10.84	103	10.12	71	3.72	30	0.31	2233
% tree pop.	83%		7%		5%		3%		1%		
Bucyrus, OH	599	12.58	91	0.59	106	46.04	70	34.51	14	0.06	880
% tree pop.	68%		10%		12%		8%		2%		
Charlottesville, VA	1216	30.93	48	48.08	36	26.67	7	39.60	11	3.77	1318
% tree pop.	90%		4%		4%		1%		1%		
Delaware, OH	1907	0.76	245	0.35	163	0.33	106	0.52	52	6.30	2473
% tree pop.	77%		10%		7%		4%		2%		
Grand Junction, CO	518	55.47 *	153	50.03	106	40.95	99	107.39 ***	36	37.12	912
% tree pop.	57%		17%		12%		11%		4%		
Hutchinson, MN	659	85.28 ***	283	248.96 ***	158	90.12 ***	88	33.64	10	3.43	1198
% tree pop.	55%		24%		13%		7%		1%		
Jamestown, NY	1450	41.04	57	56.51 *	26	53.08	20	28.68	5	14.25	1558
% tree pop.	93%		4%		2%		1%		0%		
Lincoln, NE	666	12.55	146	30.73	87	10.87	59	10.52	13	0.14	971
% tree pop.	69%		15%		9%		6%		1%		
W. Springfield, MA	1055	21.43	41	44.11	33	22.16	16	19.98	18	0.03	1163
% tree pop.	91%		4%		3%		1%		2%		
Wooster, OH	1387	2.92	144	1.73	89	2.77	39	11.89	25	0.00	1684
% tree pop.	82%		9%		5%		2%		1%		
Condition class totals / percent composition	11321	79%	1373	10%	907	6%	575	4%	214	1%	14390

* p= 0.05 level
** p= 0.01 level
*** p= 0.005 level

DF= 36

condition in Grand Junction also differed significantly. Eleven percent of all trees included in the study were reported in poor condition, significantly higher than that found in all other cities.

Significant differences were noted not only in the city of Grand Junction. The frequency of all city trees in excellent, good, and fair condition in the city of Hutchinson, MN was significantly different for each (Table 34, $p = 0.005$). While significantly fewer trees were reported in excellent condition (only 55%, the lowest of all ten cities) the frequency of trees in good condition and fair condition (24% and 13%, respectively, of total urban trees) was considerably higher. A comparative difference was also noted in the city of Jamestown, NY. Significantly fewer trees were reported in good condition.

The frequency of trees in each condition rating on public property in all 10 cities did not differ with the exception of Grand Junction (Table 35). A significantly higher frequency of trees was found in poor condition in comparison to the other cities nationwide. Twenty-seven percent of all public city trees were reported in poor condition in comparison to an average of 7.14% for the remaining nine cities. Though Grand Junction also held the highest percent of dead trees (7%), it was not found to differ significantly from the sample group. Grand Junction also had the lowest portion of public trees ranked in excellent condition, only 32%, which was far lower than the upper limits (Charlottesville, 88%) but was not found to be statistically different. All other cities appear to be similar in respect to the condition of trees on public property (Table 35).

Within the nine other sample cities, the health of the public trees in 1980 was quite good (Table 35). Public trees in only four cities, Delaware, Lincoln, Bucyrus, and Grand Junction, had over ten percent in poor condition. Trees were found to be in the worst condition in Grand Junction with 27% poor, significantly higher than all other cities. No other significant differences among the ten cities were found in the excellent, good, fair, and dead categories. Trees in the cities of Charlottesville (88% of the total population), Bowling Green (78%), Wooster (73%), West Springfield (83%), and Jamestown (73%) were found to be in the best condition and above the average of 62% although not significantly higher than that found in all other cities (Table 35).

Contrarily, no significant differences were found among trees in all age classes on private property in the city of Grand Junction in comparison to other study cities (Table 36). Though it did rank as having the lowest frequency (62%) in excellent condition and the highest frequency in poor condition (8%) these values were not found to be statistically significant. However, differences existed among the other sampled cities. The city of Hutchinson was found to differ significantly in the frequency of trees found in condition categories excellent, good, fair, and poor. While lower frequencies of Hutchinson's private trees were found in excellent condition, higher frequencies were found in the poor and fair categories. Jamestown was the only other exception with a significantly lower frequency of trees in good condition.

Table 37 summarizes the percentages of trees in each city found in excellent condition and groups those in good and fair condition as well as those in poor and dead condition.

Though this table provides only an overall average percentage in each category and does not provide any statistics on significance, it can be used to get a better overall picture of condition on public and private lands. In the city of Grand Junction, the condition of public trees appears to be worse than that found on private property. The percentage of public trees in excellent condition was far lower (32%) than the overall city average (64%) and, while the same was found on private lands (62%, 79%, respectively) to a lesser extent, less private trees were found combined in poor and dead condition (10.8% compared to 34%).

The overall condition of privately-owned trees in all cities appears to have been better than that of the publicly-owned trees. Fifty-five percent or more of the private tree populations were found to be in excellent condition. Though the private trees in the City of Grand Junction found to be in poor/dead condition was only slightly above 10% (10.8%), it was the only city above that marker.

Table 35. Chi-square test probabilities comparing condition of all trees on public property in the 10 study cities, 1980.

	Condition Classification										
	Excellent		Good		Fair		Poor		Dead		Total
City	n	Chi Square	n	Chi Square	n	Chi Square	n	Chi Square	n	Chi Square	
Bowling Green, OH	228	12.17	28	5.78	14	10.55	13	7.41	8	0.47	291
% tree pop.	78%		10%		5%		4%		3%		
Bucyrus, OH	62	10.17	15	2.50	44	44.91	27	12.27	1	1.52	149
% tree pop.	42%		10%		30%		18%		1%		
Charlottesville, VA	15	1.85	1	0.96	0	1.90	0	1.59	1	1.09	17
% tree pop.	88%		6%		0%		0%		6%		
Delaware, OH	102	0.06	14	4.27	24	2.09	19	1.09	1	1.74	160
% tree pop.	64%		9%		15%		12%		1%		
Grand Junction, CO	50	22.82	33	3.79	20	0.37	42	51.56 *	11	17.33	156
% tree pop.	32%		21%		13%		27%		7%		
Hutchinson, MN	139	2.44	75	34.60	31	0.22	10	8.03	0	5.50	255
% tree pop.	55%		29%		12%		4%		0%		
Jamestown, NY	66	1.79	14	0.01	6	1.64	3	3.48	1	0.46	90
% tree pop.	73%		16%		7%		3%		1%		
Lincoln, NE	63	3.03	27	3.34	16	0.26	19	4.43	1	1.09	126
% tree pop.	50%		21%		13%		15%		1%		
W. Springfield, MA	149	12.71	13	7.28	5	11.26	5	8.22	7	2.55	179
% tree pop.	83%		7%		3%		3%		4%		
Wooster, OH	78	1.96	11	1.64	11	0.08	5	2.50	2	0.04	107
% tree pop.	73%		10%		10%		5%		2%		
Condition class total / percent	952	62%	231	15%	171	11%	143	9%	33	2%	1530

* $p = 0.05$
** $p = 0.01$
*** $p = 0.005$

DF= 36

Table 36. Chi-square test probabilities comparing condition of all trees on private property in the 10 study cities, 1980.

	Condition Classification										
	Excellent		Good		Fair		Poor		Dead		Total
City	n	Chi Square	n	Chi Square	n	Chi Square	n	Chi Square	n	Chi Square	
Bowling Green, OH	1636	3.14	137	7.29	89	4.41	58	0.80	22	1.04	1942
% tree pop.	84%		7%		5%		3%		1%		
Bucyrus, OH	537	4.66	76	1.89	62	9.72	43	13.85	13	0.71	731
% tree pop.	73%		10%		8%		6%		2%		
Charlottesville, VA	1201	22.03	47	40.65	36	19.86	7	30.83	10	3.77	1301
% tree pop.	92%		4%		3%		1%		1%		
Delaware, OH	1805	1.93	231	3.19	139	0.33	87	1.11	51	10.45	2313
% tree pop.	78%		10%		6%		4%		2%		
Grand Junction, CO	468	32.88	120	41.63	86	42.21	57	39.33	25	19.38	756
% tree pop.	62%		16%		11%		8%		3%		
Hutchinson, MN	520	75.97 ***	208	184.38 ***	127	98.82 ***	78	67.74 ***	10	0.81	943
% tree pop.	55%		22%		13%		8%		1%		
Jamestown, NY	1384	33.91	43	58.55 **	20	48.78	17	21.17	4	13.44	1468
% tree pop.	94%		3%		1%		1%		0%		
Lincoln, NE	603	9.00	119	25.76	71	10.60	40	4.75	12	0.00	845
% tree pop.	71%		14%		8%		5%		1%		
W. Springfield, MA	906	15.98	28	40.35	28	14.24	11	14.72	11	0.59	984
% tree pop.	92%		3%		3%		1%		1%		
Wooster, OH	1309	1.10	133	0.35	78	1.66	34	6.80	23	0.03	1577
% tree pop.	83%		8%		5%		2%		1%		
Condition class total / percent	10369	81%	1142	9%	736	6%	432	3%	181	1%	12860

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 36

Table 37. Percentage of tree population of public and private trees in condition classes, ten selected U.S. cities, 1980.

Location	Public Trees				Private Trees			
	Excellent	Good/Fair	Poor/Dead	n	Excellent	Good/Fair	Poor/Dead	n
Bowling Green, OH	78.3	14.4	7.2	291	84.2	11.7	4.1	1942
Bucyrus, OH	41.6	39.6	18.7	149	73.5	18.9	7.7	731
Charlottesville, VA	88.2	5.9	5.9	17	92.3	6.4	1.3	1301
Delaware, OH	63.8	23.8	12.5	160	78	14.9	6	2313
Grand Junction, CO	32.1	34	34	156	61.9	27.3	10.8	756
Hutchinson, MN	54.5	41.6	3.9	255	55.1	35.6	9.4	943
Jamestown, NY	73.3	22.3	4.4	90	94.3	4.3	1.4	1468
Lincoln, NE	50	34.1	15.9	126	71.4	22.5	6.1	845
W. Springfield, MA	83.2	10.1	6.7	179	92.1	5.6	2.2	984
Wooster, OH	72.9	20.6	6.5	107	83	13.3	3.7	1577
Average	*63.79*	*24.64*	*11.57*	*153*	*78.58*	*16.05*	*5.27*	*1286*

Size

The percentage of each city's tree population size found within each category was compared to that found in the ten sample cities. Chi-square analysis of the entire urban forest population, inclusive of all public and private trees, found that the size structure in Grand Junction was not significantly different from that of any other city (Table 38). The percentage of saplings, those defined as having a diameter less than four inches, found in Grand Junction was 56% of the urban forest population, slightly above the ten city average of 53.2%. The same was found for small (4-10 inches in diameter), medium (11-16 inches in diameter), and large trees (over 16 inches in diameter). Small trees represented 20% of the population compared to an average of 23.3%; medium trees were 12% of the population compared to an average of 10.8%, and large trees composed 13% of the population compared to an average of 12.8%.

While no differences existed in the city of Grand Junction, several were noted in the cities of Bowling Green, Charlottesville, Delaware, Hutchinson, and Lincoln. Of the ten cities, the city of Bowling Green had the highest percentage of saplings with 70% of the population found in this group along with the lowest percentages, 5% and 7%, found in the medium and large tree categories, respectively. The opposite was found in Charlottesville, which had the least percentage (39%) of saplings and the highest percentages of medium (17%) and large trees (20%). Hutchinson and Lincoln also had high percentages of large trees (19% and 20%, respectively) while Delaware had the lowest percentage of large trees (7%).

Table 38. Chi-square test probabilities comparing size of all public and private trees in the 10 study cities, 1980.

	Size Classification												
	<4 in.			4-10 in.			11-16 in.			>16 in.			Total
City	n	Chi-square		n	Chi-square		n	Chi-square		n	Chi-square		
Bowling Green, OH	1573	98.88	***	397	30.79		111	60.24	***	152	42.08	*	2233
% tree pop.	70%			18%			5%			7%			
Bucyrus, OH	460	1.07		219	0.75		106	2.86		95	0.33		880
% tree pop.	52%			25%			12%			11%			
Charlottesville, VA	508	63.94	***	331	1.52		221	55.24	***	258	75.93	***	1318
% tree pop.	39%			25%			17%			20%			
Delaware, OH	1410	2.10		691	21.09		208	7.94		164	50.18	***	2473
% tree pop.	57%			28%			8%			7%			
Grand Junction, CO	512	0.27		180	5.41		106	1.75		114	0.87		912
% tree pop.	56%			20%			12%			13%			
Hutchinson, MN	551	17.16		280	0.00		142	3.12		225	56.19	***	1198
% tree pop.	46%			23%			12%			19%			
Jamestown, NY	784	5.85		450	19.47		194	7.58		130	13.14		1558
% tree pop.	50%			29%			12%			8%			
Lincoln, NE	462	9.38		225	0.04		88	1.28		196	64.66	***	971
% tree pop.	48%			23%			9%			20%			
W. Springfield, MA	641	0.01		224	8.77		145	5.74		153	2.95		1163
% tree pop.	55%			19%			12%			13%			
Wooster, OH	993	5.18		380	0.58		150	2.85		161	5.26		1684
% tree pop.	59%			23%			9%			10%			
Condition class total / percent	7894	55%		3377	23%		1471	10%		1648	11%		14390

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 27

Few differences were found in public tree size distributions of the ten sample cities (Table 39). Grand Junction reported a highly significant proportion of medium-sized trees, 33% of the public population, the highest in that category among the sampled cities. No other significant differences were found in Grand Junction. In Lincoln, 60% of the public tree population was composed of large trees, the most extreme of all sample cities.

Table 40 compares the privately-owned component of the urban forest. No significant differences were found in the city of Grand Junction. However, significant differences were noted in the cities of Bowling Green, Charlottesville, and Hutchinson. Bowling Green held the highest percentage of saplings (trees under four inches) on private property at 71% which was highly significant compared to the sample group. Owing to this large proportion, a significantly lower percentage, 5%, of all private trees fell into the 11-16 inch category. While most of Bowling Green's private population was represented by saplings, only 38% were saplings in Charlottesville resulting in a significantly higher proportion of medium and large trees (17% and 20%, respectively). The proportion of large trees in Hutchinson was also highly significant, making up 17% of the private population, although this did not lead to differences in other size categories.

Table 39. Chi-square test probabilities comparing size of all publicly owned trees in the 10 study cities, 1980.

City	<4 in. n	<4 in. Chi Square	4-10 in. n	4-10 in. Chi Square	11-16 in. n	11-16 in. Chi Square	>16 in. n	>16 in. Chi Square	Total
Bowling Green, OH	199	37.79	56	1.73	7	24.04	29	30.93	291
% tree pop.	68%		19%		2%		10%		
Bucyrus, OH	33	16.59	22	0.18	34	12.30	60	9.97	149
% tree pop.	22%		15%		23%		40%		
Charlottesville, VA	14	5.52	3	0.02	0	2.14	0	4.57	17
% tree pop.	82%		18%		0%		0%		
Delaware, OH	83	2.03	29	0.40	13	2.56	35	1.48	160
% tree pop.	52%		18%		8%		22%		
Grand Junction, CO	29	23.38	37	5.54	52	53.09 ***	38	0.36	156
% tree pop.	19%		24%		33%		24%		
Hutchinson, MN	105	0.59	54	4.00	31	0.04	65	0.18	255
% tree pop.	41%		21%		12%		25%		
Jamestown, NY	33	1.21	13	0.16	7	1.67	37	6.80	90
% tree pop.	37%		14%		8%		41%		
Lincoln, NE	23	19.38	7	8.75	20	1.06	76	52.50 ***	126
% tree pop.	18%		6%		16%		60%		
W. Springfield, MA	98	4.34	15	6.68	16	1.92	50	0.08	179
% tree pop.	55%		8%		9%		28%		
Wooster, OH	62	4.44	11	2.28	13	0.02	21	2.09	107
% tree pop.	58%		10%		12%		20%		
Condition class total / percent	679	44%	247	16%	193	13%	411	27%	1530

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 27

Table 40. Chi-square test probabilities comparing size of all privately owned trees in the 10 study cities, 1980.

City	<4 in. n	<4 in. Chi Square	4-10 in. n	4-10 in. Chi Square	11-16 in. n	11-16 in. Chi Square	>16 in. n	>16 in. Chi Square	Total
Bowling Green, OH	1374	74.27 ***	341	36.68	104	41.04 *	123	21.79	1942
% tree pop.	71%		18%		5%		6%		
Bucyrus, OH	427	0.69	197	2.05	72	0.01	35	17.74	731
% tree pop.	58%		27%		10%		5%		
Charlottesville, VA	494	76.25 ***	328	0.41	221	65.05 ***	258	141.05 ***	1301
% tree pop.	38%		25%		17%		20%		
Delaware, OH	1327	0.66	662	17.42	195	5.29	129	39.28	2313
% tree pop.	57%		29%		8%		6%		
Grand Junction, CO	483	8.17	143	9.14	54	5.94	76	0.15	756
% tree pop.	64%		19%		7%		10%		
Hutchinson, MN	446	13.04	226	0.05	111	3.19	160	52.93 ***	943
% tree pop.	47%		24%		12%		17%		
Jamestown, NY	751	6.40	437	17.78	187	11.59	93	16.46	1468
% tree pop.	51%		30%		13%		6%		
Lincoln, NE	439	2.60	218	0.74	68	3.04	120	18.45	845
% tree pop.	52%		26%		8%		14%		
W. Springfield, MA	543	0.15	209	3.88	129	9.96	103	0.74	984
% tree pop.	55%		21%		13%		10%		
Wooster, OH	931	2.42	369	0.57	137	2.48	140	0.91	1577
% tree pop.	59%		23%		9%		9%		
Condition class total / percent	7215	56%	3130	24%	1278	10%	1237	10%	12860

* p = 0.05
** p = 0.01
*** p = 0.005

DF= 27

DISCUSSION: Grand Junction as compared to cities nationwide, 1980

Though regional climatic variance plays an important role in determining the species composition and characteristics of the 10 cities sampled nationwide in 1980, some trends were identified and the data provided some additional background information on the status of urban forestry in Grand Junction, CO in 1980.

Generally speaking, cities in Ohio, Bowling Green, Bucyrus, Delaware, and Wooster; were consistently ranked with higher diversity indices overall and on public and private property. Grand Junction consistently ranked with average diversity, possibly reflective of management during that time.

In regard to tree condition, Grand Junction's urban forest population did not fare well compared to that found in other cities, which is likely due to climate as it was the westernmost and driest locale selected. As noted in 1980, this comparison was strikingly apparent during the first sampling (Cannon 1980). Public trees, in particular, were found to be in the worst condition, suggesting that urban trees grown in drier environments do require and benefit from more individual care. Private tree condition in Grand Junction was also significantly lower than that found nationwide, though better than that observed on publicly-owned property within the city. Public trees were found to be in poor condition suggesting that urban forestry managers should focus on better care and site-appropriate species of public trees.

Tree condition, as with species diversity, appeared to be related more to geography, as trees in eastern cities (those east of the Mississippi River) tended to be in better health than those found in the three western cities. In particular, public trees appeared to be in the worst condition in Grand Junction while private trees in Hutchinson, MN were in the worst condition, which may have been influenced by the arrival of DED.

Size did vary, as expected, among the ten sample cities, yet minimal differences were noted in Grand Junction. Most notably, more large size public trees were found in Grand Junction which may be a result of the city's western location as all other cities had been exposed to DED for several years before its effects were felt in western Colorado. Hence, many of the larger elms, which were a major component of the urban landscape for much of the last century, had been declining from disease and removed from urban streets before DED progressed westward. As indicated in notes and Grand Junction's Community Forestry Plan, large elms, though they had begun to decline, were still abundant on city streets (Cannon 1980, Denison and Winegardner, 1980).

APPENDIX B

List of species found in Age Class A (0-10 years old), Grand Junction, CO, 1980.

Species		n	% Total
Apple	*Malus spp.*	45	13.60%
Apricot	*Prunus armeniaca*	3	0.91%
Ash spp.	*Fraxinus spp.*	35	10.57%
Aspen	*Populus tremuloides*	29	8.76%
Austrian Pine	*Pinus nigra*	23	6.95%
Birch	*Betula spp.*	7	2.11%
Black Walnut	*Juglans nigra*	1	0.30%
Blue Spruce	*Picea pungens*	20	6.04%
Catalpa	*Catalpa speciosa*	2	0.60%
Cherry	*Prunus avium*	6	1.81%
Cottonwood	*Populus deltoides*	10	3.02%
Crabapple	*Malus pumila*	5	1.51%
Doug Fir	*Psuedotsuga menziesii*	2	0.60%
Honeylocust	*Gleditsia triacanthos*	8	2.42%
Lombardy Poplar	*Populus nigra var italica*	1	0.30%
Mountain Ash	*Sorbus americana*	4	1.21%
Mulberry	*Morus spp.*	2	0.60%
Norway Maple	*Acer platanoides*	1	0.30%
Norway Spruce	*Picea abies*	1	0.30%
Peach	*Prunus persica*	19	5.74%
Pear	*Pyrus spp.*	2	0.60%
Plum	*Prunus domestica*	7	2.11%
Redbud	*Cercis canadensis*	3	0.91%
Russian Olive	*Elaeagnus angustifolia*	15	4.53%
Scotch Pine	*Pinus sylvestris*	15	4.53%
Silver Maple	*Acer saccarinum*	9	2.72%
Sycamore	*Platnus occidentalus*	2	0.60%
Unknown		2	0.60%
Unknown Pine	*Pinus spp.*	1	0.30%
Western Red Cedar	*Juniperus scopulorum*	15	4.53%
White Poplar	*Populus alba*	4	1.21%
Willow spp.	*Salix spp.*	32	9.67%
	Total	331	100.00%

APPENDIX C

List of species found in Age Class B (11-40 years), Grand Junction, CO, 1980.

Species		n	% Total
Ailanthus	*Ailanthus altissima*	27	8.94%
Apple	*Malus spp.*	12	3.97%
Ash spp.	*Fraxinus spp.*	60	19.87%
Aspen	*Populus tremuloides*	4	1.32%
Austrian Pine	*Pinus nigra*	1	0.33%
Birch	*Betula spp.*	3	0.99%
Black Locust	*Robinia psuedoacacia*	1	0.33%
Black Walnut	*Juglans nigra*	5	1.66%
Blue Spruce	*Picea pungens*	6	1.99%
Catalpa	*Catalpa speciosa*	3	0.99%
Cherry	*Prunus avium*	3	0.99%
Cottonwood	*Populus deltoids*	12	3.97%
Crabapple	*Malus pumila*	7	2.32%
Elm	*Ulmus spp.*	29	9.60%
Honeylocust	*Gleditsia triacanthos*	8	2.65%
Lombardy Poplar	*Populus nigra var italica*	22	7.28%
Magnolia	*Magnolia spp.*	1	0.33%
Mulberry	*Morus spp.*	7	2.32%
Norway Maple	*Acer platanoides*	2	0.66%
Norway Spruce	*Picea abies*	1	0.33%
Peach	*Prunus persica*	7	2.32%
Pear	*Pyrus spp.*	2	0.66%
Redbud	*Cercis canadensis*	1	0.33%
Russian Olive	*Elaeagnus angustifolia*	12	3.97%
Scotch Pine	*Pinus sylvestris*	1	0.33%
Silver Maple	*Acer saccarinum*	4	1.32%
Sycamore	*Platnus occidentalus*	3	0.99%
Unknown		6	1.99%
Western Red Cedar	*Juniperus scopulorum*	24	7.95%
White Poplar	*Populus alba*	8	2.65%
White Spruce	*Picea glauca*	1	0.33%
Willow spp.	*Salix spp.*	19	6.29%
	Total	302	100.00%

APPENDIX D

List of species found in Age Class C (41 years and older), Grand Junction, CO, 1980.

Species		n	% Total
Ailanthus	*Ailanthus altissima*	36	13.19%
Apple	*Malus spp.*	5	1.83%
Apricot	*Prunus armeniaca*	4	1.47%
Ash spp.	*Fraxinus spp.*	37	13.55%
Basswood	*Tilia americana*	1	0.37%
Blue Spruce	*Picea pungens*	6	2.20%
Box Elder	*Acer negundo*	3	1.10%
Catalpa	*Catalpa speciosa*	5	1.83%
Cherry	*Prunus avium*	1	0.37%
Cottonwood	*Populus deltoides*	12	4.40%
Crabapple	*Malus pumila*	6	2.20%
Elm	*Ulmus spp.*	48	17.58%
Honeylocust	*Gleditsia triacanthos*	20	7.33%
Lombardy Poplar	*Populus nigra var italica*	1	0.37%
Magnolia	*Magnolia spp.*	1	0.37%
Mountain Ash	*Sorbus americana*	2	0.73%
Mulberry	*Morus spp.*	8	2.93%
Norway Spruce	*Acer platanoides*	2	0.73%
Peach	*Prunus persica*	6	2.20%
Plum	*Prunus domestica*	4	1.47%
Ponderosa Pine	*Pinus ponderosa*	1	0.37%
Russian Olive	*Elaeagnus angustifolia*	3	1.10%
Scotch Pine	*Pinus sylvestris*	2	0.73%
Sumac	*Rhus spp.*	2	0.73%
Sycamore	*Platnus occidentalus*	21	7.69%
Western Red Cedar	*Juniperus scopulorum*	26	9.52%
White Poplar	*Populus alba*	1	0.37%
Willow spp.	*Salix spp.*	9	3.30%
		273	100.00%

APPENDIX E

List of species found in Age Class A (0-34 years old), Grand Junction, CO, 2004.

Species		n	% Total
Ailanthus	*Ailanthus altissima*	6	0.89%
Amur Maple	*Acer ginnala*	1	0.15%
Apple	*Malus spp.*	50	7.45%
Apricot	*Prunus armeniaca*	4	0.60%
Ash spp.	*Fraxinus spp.*	69	10.28%
Aspen	*Populus tremuloides*	107	15.95%
Austrian Pine	*Pinus nigra*	31	4.62%
Birch	*Betula spp.*	7	1.04%
Black Walnut	*Juglans nigra*	3	0.45%
Blue Spruce	*Picea pungens*	34	5.07%
Callery Pear	*Pyrus calleryana*	2	0.30%
Catalpa	*Catalpa speciosa*	2	0.30%
Cherry	*Prunus avium*	15	2.24%
Cottonwood	*Populus deltoides*	15	2.24%
Crabapple	*Malus pumila*	17	2.53%
Doug Fir	*Psuedotsuga menziesii*	2	0.30%
Elm	*Ulmus spp.*	3	0.45%
European Birch	*Betula pendula*	1	0.15%
Gray Birch	*Betula populifolia*	1	0.15%
Hawthorne	*Crataegus spp.*	1	0.15%
Honeylocust	*Gleditsia triacanthos*	22	3.28%
Lombardy Poplar	*Populus nigra var italica*	3	0.45%
Mountain Ash	*Sorbus americana*	5	0.75%
Mugo Pine	*Pinus mugo*	2	0.30%
Mulberry	*Morus spp.*	13	1.94%
Norway Maple	*Acer platanoides*	2	0.30%
Norway Spruce	*Picea abies*	1	0.15%
Oriental Arborvitea	*Platycladus orientalis*	8	1.19%
Peach	*Prunus persica*	24	3.58%
Pear	*Pyrus spp.*	5	0.75%
Pinyon Pine	*Pinus edulis*	2	0.30%
Plum	*Prunus domestica*	10	1.49%
Ponderosa Pine	*Pinus ponderosa*	13	1.94%

Red Maple	*Acer rubrum*	3	0.45%
Redbud	*Cercis canadensis*	9	1.34%
Russian Olive	*Elaeagnus angustifolia*	20	2.98%
Scotch Pine	*Pinus sylvestris*	15	2.24%
Silver Maple	*Acer saccarinum*	13	1.94%
Sycamore	*Platnus occidentalus*	5	0.75%
Unknown		3	0.45%
Unknown Maple	*Acer spp.*	2	0.30%
Unknown Pine	*Pinus spp.*	2	0.30%
Western Red Cedar	*Juniperus scopulorum*	43	6.41%
White Birch	*Betula papyrifera*	1	0.15%
White Cedar	*Thuja occidentalis*	11	1.64%
White Oak	*Quercus spp. (Lepidobalanus)*	3	0.45%
White Poplar	*Populus alba*	15	2.24%
White Spruce	*Picea glauca*	2	0.30%
Willow spp.	*Salix spp.*	43	6.41%
		671	100.00%

APPENDIX F

List of species found in Age Class B (35-60 years), Grand Junction, CO, 2004.

Species		n	% Total
Ailanthus	*Ailanthus altissima*	31	4.28%
Amur Maple	*Acer ginnala*	1	0.14%
Apple	*Malus spp.*	38	5.25%
Apricot	*Prunus armeniaca*	5	0.69%
Ash spp.	*Fraxinus spp.*	100	13.81%
Aspen	*Populus tremuloides*	63	8.70%
Austrian Pine	*Pinus nigra*	16	2.21%
Birch	*Betula spp.*	3	0.41%
Black Locust	*Robinia psuedoacacia*	8	1.10%
Black Walnut	*Juglans nigra*	5	0.69%
Blue Spruce	*Picea pungens*	26	3.59%
Box Elder	*Acer negundo*	1	0.14%
Callery Pear	*Pyrus calleryana*	1	0.14%
Catalpa	*Catalpa speciosa*	7	0.97%
Cherry	*Prunus avium*	35	4.83%
Cottonwood	*Populus deltoides*	18	2.49%
Crabapple	*Malus pumila*	19	2.62%
Elm	*Ulmus spp.*	45	6.22%
European Birch	*Betula pendula*	2	0.28%
Honeylocust	*Gleditsia triacanthos*	27	3.73%
Lodgepole Pine	*Pinus contorta*	1	0.14%
Lombardy Poplar	*Populus nigra var italica*	29	4.01%
Magnolia	*Magnolia spp.*	1	0.14%
Mugo Pine	*Pinus mugo*	1	0.14%
Mulberry	*Morus spp.*	14	1.93%
Norway Maple	*Acer platanoides*	2	0.28%
Norway Spruce	*Picea abies*	1	0.14%
Oriental Arborvitea	*Platycladus orientalis*	5	0.69%
Peach	*Prunus persica*	10	1.38%
Pear	*Pyrus spp.*	4	0.55%
Pinyon Pine	*Pinus edulis*	1	0.14%
Ponderosa Pine	*Pinus ponderosa*	3	0.41%
Red Maple	*Acer rubrum*	1	0.14%

Redbud	*Cercis canadensis*	1	0.14%
Russian Olive	*Elaeagnus angustifolia*	25	3.45%
Scotch Pine	*Pinus sylvestris*	7	0.97%
Silver Maple	*Acer saccarinum*	19	2.62%
Sumac	*Rhus spp.*	2	0.28%
Sycamore	*Platnus occidentalus*	7	0.97%
Unknown		6	0.83%
Unknown Maple	*Acer spp.*	1	0.14%
Unknown Pine	*Pinus spp.*	3	0.41%
Western Red Cedar	*Juniperus scopulorum*	55	7.60%
White Cedar	*Thuja occidentalis*	11	1.52%
White Poplar	*Populus alba*	21	2.90%
White Spruce	*Picea glauca*	2	0.28%
Willow spp.	*Salix spp.*	40	5.52%
		724	100.00%

APPENDIX G

List of species found in Age Class C (61 years and older), Grand Junction, CO, 2004.

Species		n	% Total
Ailanthus	*Ailanthus altissima*	137	15.36%
Alder	*Alnus spp.*	2	0.22%
Apple	*Malus spp.*	12	1.35%
Apricot	*Prunus armeniaca*	6	0.67%
Ash spp.	*Fraxinus spp.*	65	7.29%
Aspen	*Populus tremuloides*	27	3.03%
Austrian Pine	*Pinus nigra*	1	0.11%
Basswood	*Tilia americana*	1	0.11%
Blue Spruce	*Picea pungens*	18	2.02%
Box Elder	*Acer negundo*	4	0.45%
Callery Pear	*Pyrus calleryana*	2	0.22%
Catalpa	*Catalpa speciosa*	10	1.12%
Cherry	*Prunus avium*	4	0.45%
Cottonwood	*Populus deltoides*	20	2.24%
Crabapple	*Malus pumila*	7	0.78%
Dogwood	*Cornus spp.*	1	0.11%
Elm	*Ulmus spp.*	211	23.65%
Golden Raintree	*Koelreuteria paniculata*	2	0.22%
Hackberry	*Celtis occidentalis*	2	0.22%
Honeylocust	*Gleditsia triacanthos*	80	8.97%
Lodgepole Pine	*Pinus contorta*	1	0.11%
Lombardy Poplar	*Populus nigra var italica*	1	0.11%
Magnolia	*Magnolia spp.*	1	0.11%
Mountain Ash	*Sorbus americana*	3	0.34%
Mugo Pine	*Pinus mugo*	3	0.34%
Mulberry	*Morus spp.*	54	6.05%
Norway Maple	*Acer platanoides*	4	0.45%
Norway Spruce	*Picea abies*	2	0.22%
Paulownia	*Paulownia tomentosa*	1	0.11%
Peach	*Prunus persica*	7	0.78%
Pear	*Pyrus spp.*	6	0.67%
Pladycladus	*Platycladus orientalis*	9	1.01%
Plum	*Prunus domestica*	7	0.78%

Ponderosa Pine	*Pinus ponderosa*	11	1.23%
Russian Olive	*Elaeagnus angustifolia*	8	0.90%
Scotch Pine	*Pinus sylvestris*	3	0.34%
Silver Maple	*Acer saccarinum*	8	0.90%
Sugar Maple	*Acer saccharum*	1	0.11%
Sumac	*Rhus spp.*	2	0.22%
Sycamore	*Platnus occidentalus*	34	3.81%
Unknown		3	0.34%
Unknown Pine	*Pinus spp.*	1	0.11%
Western Red Cedar	*Juniperus scopulorum*	88	9.87%
White Cedar	*Thuja occidentalis*	1	0.11%
White Oak	*Quercus spp. (Lepidobalanus)*	3	0.34%
White Poplar	*Populus alba*	6	0.67%
White Spruce	*Picea glauca*	2	0.22%
Willow spp.	*Salix spp.*	10	1.12%
		892	100.00%

APPENDIX H

Urban tree attitude questionnaire, 2004.

COVER LETTER MAILED WITH SURVEY

MICHIGAN STATE UNIVERSITY
URBAN TREE ATTITUDE STUDY, GRAND JUNCTION, CO.

October 13, 2005

Greetings:
Your neighborhood has been involved in research conducted by Michigan State University, Department of Forestry. Led by Dr. J.James Kielbaso, the study will analyze trends in the urban forest throughout the City of Grand Junction.

The study was conducted during the years of 1980 and 2004. Trees on both private and public property (the area between the sidewalk and the curb) were surveyed in randomly selected blocks throughout the city. Information was collected on tree species, size, and the condition. The data will be used to compare and determine trends in the urban forest from 1980 to present.

Additionally, the study seeks to determine resident attitudes towards trees in general in the City of Grand Junction. The enclosed survey requires *very little written response and will take very little of your time*. The survey does not require you to identify yourself and your responses will neither be linked to you nor your residence. The responses will be used for statistical research purposes only and you will remain anonymous. *The information gathered is critical to the success and accuracy of the study* and can be used to improve the natural environment and quality of life in your city. Return postage has also been provided on the enclosed stamped envelope.

Please feel free to contact Ms. Heidi Frei (contact information below) with any questions you may have.
Thank you for taking the time to improve your community forest and your city.

Sincerely,

____

Heidi Frei
Research Assistant
MSU, Dept. of Forestry
Natural Resources Building
East Lansing, MI 48824
freiheid@msu.edu

QUESTIONNAIRE

MICHIGAN STATE UNIVERSITY
EVALUATING YOUR NEIGHBORHOOD STREET TREES

The following questions refer to the trees growing along the street in your immediate neighborhood, that is, within a block or two of your house, apartment, or place of business. This research is attempting to find out how these trees contribute to the quality of life in your neighborhood. The questionnaire will only take a few minutes to fill out. THANK YOU!

1. Here are some possible positive features of street trees. Please check below the degree of benefit you receive from these trees.
Please check only one box per line.

		No benefit	*Slight* benefit	*Some* benefit	*Great* benefit	*Very great* benefit
a.	Provides shade					
b.	Pleasing to the eye					
c.	Flowers on trees					
d.	Autumn color					
e.	Neighborhood more livable					
f.	Reduce noise					
g.	Cools building in summer					
h.	Slows wind speed					
i.	Increases privacy					
j.	Filters dust from air					
k.	Increases property value					
l.	Brings nature close					
m.	Attract birds/wildlife					
n.	Gives sense of pride					

2. What type(s) of things would you like to see more of in your local parks?
PLEASE NUMBER 1,2,3....10 FROM MORE IMPORTANT (1) TO LEAST IMPORTANT (10).

_____ picnic area
_____ basketball court
_____ garden / flower beds
_____ soccer field
_____ playground equipment
_____ tennis court
_____ volleyball court
_____ walking / biking path
_____ benches
_____ trees and shrubs
_____ other _________

3. Here are some possible negative features of street trees. Please check below the degree of annoyance you receive from these trees.
Please check only one box per line.

		Not an annoyance	*Slight* annoyance	*Some* annoyance	*Great* annoyance	*Very great* annoyance
a.	Sidewalks damaged					
b.	Insect/disease in tree					
c.	Branches break power lines in storm					
d.	Suckers grow around base of the tree					
e.	Fruit or seeds fall					
f.	Flower parts fall					
g.	Falling leaves in autumn					
h.	Falling branches					
i.	Darkens street at night					
j.	Causes allergies					
k.	Limited visibility reduces security					
l.	Blocks sun in winter					
m.	Branches block line of sight					
n.	Roots clog up sewer					

5. Would you be willing to participate in these programs if available?

		Yes	Maybe/Don't Know	No
a.	Ecological programs in general	_____	_____	_____
b.	Arbor Day programs	_____	_____	_____
c.	Environmental education program	_____	_____	_____
d.	Voluntary service program	_____	_____	_____
e.	Adopt a street program	_____	_____	_____
f.	other ____________________	_____	_____	_____

6. What is your overall opinion of the condition of the street trees in your neighborhood?

_____ excellent _____ very good _____ good _____ poor _____ very poor

Why do you feel this way?

____

7. Do you feel that the size of the street trees in your neighborhood is:

_____ too small _____ just right _____ too large _____ no opinion

8. The pruning of street trees in you neighborhood is:

_____ excellent _____ very good _____ good _____ poor _____ very poor

9. How well do you think that the City is maintaining the street trees?

_____ excellent _____ very good _____ good _____ poor _____ very poor

10. Do you feel that more trees should be planted in the City?

If yes, where? _____ Yes _____ No

_____ streets _____ parks _____ plazas _____ own yards _____ other

11. Do you participate in recycling?

_____ yes _____ no _____ sometimes

12. How important to you are trees and shrubs in the following areas?
Please check only one box per line.

	Not important	*Slightly* important	*Somewhat* important	*Greatly* important	*Very* important
a. in a city park	_____	_____	_____	_____	_____
b. in downtown shopping areas	_____	_____	_____	_____	_____
c. in front yards of homes	_____	_____	_____	_____	_____
d. along residential streets	_____	_____	_____	_____	_____
e. in and around parking lots	_____	_____	_____	_____	_____
f. in industrial areas	_____	_____	_____	_____	_____
g. in backyards of homes	_____	_____	_____	_____	_____

13. Would you be willing to pay for more of the following community services?

	Yes	No	No opinion
a. recreational programs	_____	_____	_____
b. parks	_____	_____	_____
c. environmental education	_____	_____	_____
d. street trees	_____	_____	_____
e. bicycle path	_____	_____	_____
f. other _______________	_____	_____	_____

15. Here are some statements regarding the City of Grand Junction and its environment. Check the box that you feel best describes the statement.
Please check only one box per line.

		Strongly agree	Agree	Not sure/ don't know	Disagree	*Strongly disagree*
a.	The city is a model of urban planning.					
b.	Trees contribute to the quality of life in the city.					
c.	My neighborhood is well-planned.					
d.	The city is ecologically conscious.					
e.	Trees influence my choice of a place to live.					
f.	The city should preserve more green/natural areas.					
g.	The city needs to improve the quality of its urban tree plantings.					

17. The following questions are for statistical purpose only- you will not be identified.

a. How long have you occupied this house / building? ____ years

b. Do you own or rent? ____ own ____ rent ____ rent to own

c. Are you: ____ Male ____ Female

d. Your age: ____ 18-25 ____ 26-35 ____ 36-45 ____ 46-60 ____ 60+

e. Your education (circle highest level achieved):

Grade school High school College: Associates Bachelors Masters PhD.

f. What is your approximate monthly household income?

____ Less than $2,000 ____ $3001 - 4,000 _____ over $5,000

____ $2,001 - 3,000 ____ $4,001 - 5,000

Thank you! Please use the enclosed envelope for your convenience.

FOLLOW-UP SURVEY LETTER

MICHIGAN STATE UNIVERSITY
EVALUATING YOUR NEIGHBORHOOD STREET TREES

November 23, 2005

Greetings:
A survey was mailed to you during the month of October to assist in research at Michigan State University, Department of Forestry. The survey, part of a study conducted during the years of 1980 and 2004, will assess resident attitudes towards trees in general in the city.

For whatever reason, a number of surveys have not been completed and returned. Using the return rate, I have randomly selected a percentage of addresses to resend the survey. If you have already completed your survey, I sincerely thank you. If you have not yet had the opportunity, please take the time to assist in our research.

Although the upcoming season is typically busy for all, we would greatly appreciate your time and effort. Please remember that the survey requires very little written response and very little time to complete and you will remain anonymous. *The information gathered is critical to the success and accuracy of the study* and can be used to improve the natural environment and quality of life in your city. Return postage has also been provided on the enclosed stamped envelope.

Please feel free to contact Ms. Heidi M. Frei (contact information below) with any questions you may have.

Thank you for taking the time to improve your community forest and your city.

Sincerely,

____

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