Spring 5-12-2016

Giving Trees: Protecting our Urban Forest

Catherine C. LaPerche
Fordham University, claperche@fordham.edu

Follow this and additional works at: http://fordham.bepress.com/environment_2015

Recommended Citation
Giving Trees:

Protecting our Urban Forest

Catherine LaPerche

Submitted in completion of the Environmental Studies Major

Fordham University

May 2016
Abstract

Over 80% of Americans live in urban areas and that percentage is expected to rise in the coming years. As young people migrate toward cities and the global population rises it is estimated that over 6 billion people will live in urban areas by 2045. The city of the future will not only have to face this population pressure but will also have to deal with rising sea levels, unpredictable weather patterns, increasing energy costs, rising temperatures, and decreasing air quality. Cities that will thrive in this unfavorable future must have strategic plans that will address and alleviate these crucial issues. To lead a municipality down this critical path we must examine the benefits of ecosystem services, environmental history, economic analysis, and administrative structure.

When people hear the word ‘forestry’ they often think of thousands of acres of mighty evergreens lining the great American West, rarely do they think of the street trees which stand outside their door. Equipping American cities with a diverse and robust urban forest will improve public health, mitigate the effects of climate change, and increase energy efficiency. By introducing policy which promotes innovative communication and partnerships with local organizations that have a vested interests in the benefits of an urban forest, stewardship programs can be created to monitor and protect this resource. Programs such as these can help reclaim our ecosystems as well as provide a means to strengthen community bonds and increase environmental awareness.
# Table of Contents

Table of Contents 3

Introduction: Solutions Growing in your Backyard 4

Chapter 1: One, Two, Tree: Running the Numbers on Ecosystem Services 5

Chapter 2: Finding Your Roots: Environmental History 24

Chapter 3: Economic Analysis 39

Chapter 4: Politics and Administration of Urban Forestry Programs 45

Chapter 5: Policy Recommendations: Everything is Going to be *Oak* 51

Bibliography 55
Introduction: Solutions Growing in your Backyard

It is clear North American cities face a slew of problems. Outdated transportation systems congest cities, filling the air with pollutants which damage public health as well as the atmosphere. These cities are home to failing infrastructures that increase maintenance cost due to shortfalls of efficiency. Substandard education hinders communities’ ability to make better pay and to rise out of poverty. Municipal budgets are strained by increasing energy costs and poor access to clean food and water. The current effects of climate change throw rising sea levels, extreme storms and droughts, and heat waves into the troubling mix. It is also clear that rapid biodiversity loss as well as climate change will bring economic and social disarray to not only these cities but also the entire global community. Urban governments are turning to the benefits of green infrastructure to combat the internal and external issues they face. While the benefits of green space are becoming more widely accepted and introduced, the powerful advantages of urban forestry have been overlooked. In order to demonstrate the need to revitalize our urban forests, I will explain the roll forests play in Earth’s natural cycles as well as the ecosystem services they provide. In addition, communicating the environmental history of North America will show how people of the past thrived or failed due to their relationship with their surrounding resources. I will analyze economic benefits urban forestry can bring to the forestry industry as well as how it can help improve urban economies. Then, I will provide an update on the state of U.S urban forestry programs and detail the political and administrative issues facing these programs. Finally, I will provide concrete policy recommendations demonstrating how North American cities can engage communities on the benefits trees while also providing the means to survey and enhance the urban forest.
Chapter 1: One, Two, Tree: Running the Numbers on Ecosystem Services

Our surroundings deeply affect our lives. Humans can build their environment and therefore have a huge influence on the world they live in. These choices of surroundings are rarely made by the billions of individuals on Earth, but instead are collectively made over time. Often the privileged elite heavily influences the decision of what world we chose to shroud ourselves in. Recently in the United States, citizens have begun to understand the power of groups working together and have demanded a better environment. In many places this call has been recognized and has begun to be pursued. How we choose to plan, design, and manage our surroundings will not only affect us but also the generations of humans that come after us.

Cities are mosaics of land, housing, transportation, culture, urban planning, health, economics, and politics. Along with our realization of how we influence our quality of life, we have also begun to understand how our choices affect the state of the global community. Our concrete worlds have proven they only provide us and our fellow species so much.

State of the City. To understand the state of the U.S city we need to examine its current and future problems. Between 2000 and 2010 the urban population has increased by 12.1%. This growth pace exceeds the national growth rate of 9.7%, implying a trend of rapid urbanization. Cities are defined as “densely developed residential, commercial and other nonresidential areas” by the U.S Census. As of 2010, urban areas hold 80% of the U.S population. To prepare for this influx cities need to start planning and updating themselves to not only accommodate this growth but also design cities aimed at improving the condition of humanity and the environment.

A sound infrastructure is the foundation for a vital city. Functioning infrastructures allows for continued economic well-being. Roads that can not handle job commutes, public

1 United States Census Bureau. “Growth in Urban Population Outpaces Rest of Nation, Census Bureau Reports”,

LaPerche 5
transportation, emergency services, and access to stores, schools, and hospitals can disrupt local economies and push them toward decline. Failing water supply networks and wastewater collection systems will weaken public health and endanger economic growth. Infrastructure has been a low priority for federal and local governments burdened by debt and liquidity problems. As infrastructure falls behind and rapid growth continues the U.S is headed toward a debilitating future.

The high densities of cities promote poor air and water quality. Cities host concentrations of power plants, industry, motor vehicles, trains, planes, and incinerators all of which burn fossil fuels and increase air pollution within an area. Water pollutants can be traced to factories, wastewater treatment plants, fertilizers, and pesticides. As a city’s population grows the frequency of these air and water contaminants grows as more of these point sources operate to accommodate the needs of a rising population.

Rising populations also threaten outdated urban wastewater systems. Due to the high demand of water in cities, canals must often be built which steal water from surrounding habitats. The lack of water in nearby habitats can cause a loss of plant and animal life and worsen biodiversity loss. Increasing volumes of wastewater force a city to handle the increased likelihood of untreated wastewater being released into waterways. This untreated wastewater can damage both environmental and human health. In addition, an increasing population will undoubtedly lead to increases in energy consumption and energy cost.

The built environment has a huge effect on public health. The construction of our cities is the groundwork of daily life and influences physical, mental, and emotional health. Urban areas are great benefits to public health, providing easy access to medical care, food, family, friends,

---

and education. Studies show living in close communities can be more beneficial to health than living in isolated rural areas. However, community benefits are dependent upon the closeness of a community’s ties and its ability to provide goods and services efficiently. When factors of the built environment weaken physical, mental, and emotional health communities are strained. Overpopulation can aggravate a community’s ability to stably operate and also spreads efforts to improve the built environment thin.

**Climate Change.** More scientific research comes forward each day proving our climate is changing. Our climate, or the average weather conditions over a long period of time, is warming. The planet has natural periods of warming and cooling as is evident by the measurement of temperatures over the past 900,000 years. But in recent years, we have seen a spike in the in climate temperatures and science has directly linked it with the influx of greenhouse gases in our atmosphere. The chart below shows how the influx of temperatures over the past 400,000 years directly follows the rise and falls of the amount of greenhouse gases in the atmosphere. Between 1906 and 2005 the global temperature has risen by 0.74 degrees Celsius. This rise in temperature is extremely significant. It is estimated that if global temperatures were to rise 3 degrees higher, the effects of climate change would break down several ecological, economic, and social systems. Today glaciers are already melting and floating ice is shrinking at an alarming rate. Every year between 1970 and 2009 our greenhouse gas emissions have increase 70%. This evidence as well as the scientific principle that greenhouse gases (which have been building up in our atmosphere) contain symmetrical elements that absorb radiation, must lead us to the conclusion that climate change is real.

---

Climate change brings its own multitude of problems to the urban community. In North America, a higher global temperature will cause decreased snowpack, resulting in more winter flooding. Decreased snowpack will increase competition for water resources among cities sourcing their water from streams, rivers, and deltas. The northeast will experience sporadic heavy rainfall, stressing outdated wastewater systems. Heat waves in North America will occur at increased frequency, intensity, and duration, posing a threat to public health. As sea levels rise cities will experience mass migration of climate change refugees. This increase in population will demand further development into natural areas, increasing the risk of air and water pollution.

Our only hope to prevent the onset of climate change is action. Improving environmental education throughout the U.S is key. This eye opening education will force the hand of the public to act. Reducing and preventing greenhouse gas emissions should be a first priority; a strategy of reducing greenhouse gases through green infrastructure and an efficient switch to a renewable

---


energy powered economy. Reducing deforestation, slowing population growth, and using more sustainable practices in our everyday lives are other ways we can act as a global community to stop a common enemy. If humans are to survive and prosper into the future we need to take action.

The benefits of ecosystem services can help the city of today and tomorrow face these ecological, economic, and political problems. Natural ecosystems provide humans with provisioning, regulating, and cultural services. A provisioning service is a physical output from an ecosystem used by humans, such as food and water. Regulating services regulate the quality of systems humans partake in, such as soil and air moderation. A cultural service is a non-material benefit that contributes to the cultivation of social-well-being through interactions with nature.\(^7\)

Human are dependent on these services. Without these services human well-being declines. Simply imagine a world without natural vegetation or biodiverse ecosystems. This world is alien to the life we know. Without these systems life would be utterly unrecognizable and the removal of them from our current world would set forward astronomical change. These services bolster a community’s security, health, basic needs, and social relations. Investing in the perseveration and cultivation of these services directly affects the long-term vigor of humanity.

Urban Forest. The benefits of forests have been researched, documented, and acknowledge for a long time. However, the benefits trees can bring to cities have only recently been recognized. Trees are planted on streets, in parks, and on private property, but residents and policy makers don’t view themselves as dwellers within an urban forest, instead they feel as if they live apart from nature. This mindset has led to a lack of attention to city trees. Most cities do not have an integrated plan for the preservation, cultivation, and development for the thousand of trees within their borders. Most people think trees do not require the care often give to other vegetation. Yet because of this lack of care, trees are urban plants subject to many threats. Invasive species and disease have been known to decimate tree populations. When trees are not routinely monitored or managed these threats can wipe out hundreds of thousands of trees in a concentrated area. The air pollutants trees remove also threatens their health. In order to make sure these trees continue to removes these harmful gases their health needs to be measured to

---

extend their lives. Urban trees also suffer from poor soil quality, trash, dog urine, storms, power lines, and physical damage from human activity. A demonstration of the multitude of ecosystems services delivered by urban trees will convey why the management of urban trees should be a responsibility of public and private owners.

**Aesthetic Uses.** Americans find grass and trees an important part of their aspirations. A home near these resources is a common wish for the average American. When deciding on a neighborhood to move to the present of trees weighs just as heavily as the presence of “friendly neighbors, churches, schools, and good stores nearby.” According to a 1970’s poll, 95% of American believed an aesthetically pleasing landscape was important for communities.

**Temperature Regulation.** The healthy temperature of a human being is around 98.6°F, give or take a few degrees. Cities are warmer than rural or suburban areas by 32 to 34°F. In cities, radiation from the sun is absorbed by surfaces unique to cities, such as asphalt, concrete, steel, and tar roofs. These materials are very good at absorbing heat but as not as good at holding on to that heat. As a result, this “urban heat island effect” causes air surrounding these common objects to increase in temperature and decrease in humidity. Introducing trees into urban areas is a great way to ameliorate this effect. Trees intercept this heat and either reflect, absorb, or transmit it. By eliminating this excess heat, trees lower city temperatures. Conversely, trees release this heat in the winter through the lost of their leaves, thus increasing winter temperatures. Trees further decrease the effects of urban heat through evapotranspiration, the act of trees releasing water through leaves and soil. A single tree can transpire 88 gallons of water a day. This cooling of the atmosphere by a single tree is similar to 5 air conditioners.

---

10 Ibid., 51
running for 20 hours a day. Trees can lessen the effects of urban heat to make areas more comfortable and livable.

![Image: Fig. 3: Temperature and humidity regulation by trees](image)

**Wind Protection.** Surprisingly, summer winds can make cities warmer. Wind can replace cool, humid air under tree canopies with warm, dry air increasing the temperature. Trees can decrease wind velocity and therefore keep cool air under its canopy. Densely plant trees and shrubs are able to reduced wind speed up to 80%. Trees and shrubs can also be used to deflect wind around buildings. The protection of a windbreak largely depends on the density and height of the break; taller dense windbreaks allow for larger distances of protection. Tree windbreaks are excellent providers of wind protection for streets and highways. Streets and highways often run perpendicular to wind currents, precise planting of trees can prevent strong winds from blowing through these busy areas, increasing the safety of roads. Trees are also useful in controlling the forming of snowdrifts. When trees act as windbreaks they can prevent the formation of narrow and deep snowdrifts. Trees can be strategically planted to prevent snowdrifts occurring on roads.

**Heating/Cooling.** Buildings lose heat through air infiltration and heat conduction. Air infiltration occurs when strong winds strike a building, creating high pressure on the wind side.

---

12 Ibid., 47
13 Ibid., 48
14 Ibid., 52
15 Ibid., 50
and low pressure on the opposite side. The difference in pressure pushes the warm air inside a building, up and out through the ceiling and walls, while pulling cold air outside in through the floor and walls. Air infiltration can reduce heat in a building by up to 50%. As illustrated above trees can decrease wind velocities and thus reduce air infiltration.\textsuperscript{16} Heat conduction transfers heat from warm objects to cold objects, the interior surfaces of walls, floors, ceilings and windows lose heat to their exterior sides. During winter, the trees lined next to homes can create insulation zones that prevent heat from being pulled out of homes. Strategic planting near homes can save up to 20% on fuel cost.\textsuperscript{17}

Trees can also help cool homes and reduce energy demands in the summer. When solar radiation hits windows, the interior surfaces become warmer. Trees surrounding homes can intercept 90% of solar heat from reaching windows and walls. Summer heat conduction transfers heat inside homes though walls and can be reduced through tree insulation zones. All in all, landscaping can reduce heating and cooling cost from 8 to 12%.\textsuperscript{18}

**Soil Erosion.** Soil erosion is defined as “poor soil preservation causing a loss of topsoil due to water or wind movement.”\textsuperscript{19} Topsoil is the highest layer of soil and contains the highest concentration of mineral particles, organic matter, water, air, and microorganism in soil. The richness of this layer provides plants with the nutrients necessary for survival. A degradation of topsoil severely endangers the ability of all species to provide for themselves. It takes 2,000 years to accumulated 10 centimeters of topsoil, but unfortunately it can be blown or washed away in a day. Therefore it is imperative that we protect our soil from eroding practices.

\begin{itemize}
\item \textsuperscript{16} Miller, *Urban Forestry: Planning and Managing Urban Greenspaces*, 60
\item \textsuperscript{17} Grey and Deneke, *Urban*, 50
\item \textsuperscript{18} Miller, *Urban Forestry: Planning and Managing Urban Greenspaces*, 62
\item \textsuperscript{19} Grey and Deneke, *Urban*, 60
\end{itemize}
Urban areas are particularly subject to erosion due to widespread construction, use of impervious materials, neglect of soil, and over use of green space. During construction vegetation is wiped out of an area, leaving topsoil exposed to wind. Broad urban use of impervious material such as concrete, asphalt, and metal prevent water infiltrating soil and recharging ground water. Water that meets impervious surfaces collects and increases the intensity of water flow over soil.\textsuperscript{20}

Soil erosion decreases water quality through causing eutrophication of lakes and rivers. The introduction of phosphorus and nitrogen rich topsoil causes bodies of water to experience a boom in plant and algae growth. Algae booms as well as new soil sediment increase turbidity, or cloudiness, making it harder for sunlight to reach aquatic plants. When plants die from lack of sunlight, their decomposition process depletes the water of oxygen. Low oxygen levels create a positive feedback loop, causing more plants as well as other forms of aquatic life to die and decompose, further decreasing oxygen levels.\textsuperscript{21}

Trees prevent precipitation from overwhelming soil and are an integral part of the hydrological cycle. When trees block or absorb precipitation, soil is not inundate allowing for water to be filtered through the soil at a slower pace. With less flooding of soil, water runoff is reduced and the risk of soil erosion decreases. To cities sourcing their water from underground aquifers, trees are essential to recharging these aquifers with clean water.\textsuperscript{22} Trees and shrubs also have strong root structures that can help hold soil in place, preventing both wind and water caused erosion. Erosion also occurs when open vegetative space, such as lawns, are overused resulting in weaken root structures. The weakened root structures poorly hold soil in place.

\textsuperscript{20} Miller, \textit{Urban Forestry: Planning and Managing Urban Greenspaces}, 75
\textsuperscript{22} Grey and Deneke, \textit{Urban}, 56
Strategic use of trees in landscape planning can be used to prevent heavy foot traffic on vegetative surfaces.

**Watershed Protection.** As illustrated, urbanization increases soil erosion thus increasing runoff and decreasing soil absorption and groundwater recharge. All of these side effects have a negative affect on a city’s watershed. The resulting influx in water volume allows for less water to infiltrate the soil surrounding waterways, resulting in flooding. Planting trees and shrubs helps reduce large water volumes reaching the watershed.23

**Wastewater Management.** The urban population will rise and with it municipal sewage waste will rise as well. Not only will the increase in population cause creation of more water waste in homes but it will also lead to the creation of more wastewater infrastructures (streets, bridges, buildings). Currently many urban areas, especially northeastern cities, already have difficulty dealing with large amounts of wastewater.

Combined sewer systems collect household sewage, industrial sewage, and rain runoff in the same piping. Combined sewer systems transport water to treatment plants before they are released into waterways. However, during heavy rain and snowmelt treatment plants can not handle the influx in water volume. When a combined sewer system exceeds its water volume capacity it is designed to release large amounts of untreated wastewater into waterways. This untreated wastewater can contain trash, pharmaceutical drugs, bacteria, pathogens, metals, human waste, toxics, and other pollutants.

_____________________________
23 Ibid., 61
This discharge is both an environmental hazard and a public health concern. Organic compounds, metals, oil, grease, and toxic pollutants harm the health and habitats of aquatic life. The nitrogen, phosphorous, and oxygen demanding organic material can also cause algae booms in these waters. Combined sewage overflows are the cause for most beach closures. When overflow reaches beaches high levels of bacteria as well as floatable objects such as condoms, tampon applicators, fecal matter, grease, and food force beaches to shut down for health reasons. These pollutants can contaminate drinking water, spreading diseases such as hepatitis, gastric disorders, dysentery, swimmer’s ear, typhoid, cholera, and dysentery. 772 cities in the U.S have a combined sewer systems, and most of these cities surround critical bodies of water such as the Atlantic Ocean, Pacific Ocean, and the Great Lakes. Discharge sites are often located close to heavily populated areas.

25 Ibid.
Amendments made to the 2000 Clean Water Act required combined sewer municipalities to attain a permit for releasing this pollution from the National Pollutant Discharge Elimination System program. This program provides water quality standards that cities must comply with and also forces cities to impose ‘nine minimum controls’ which reduce combined sewer overflow. These ‘minimum controls’ focus on maintenance and modification to sewer systems. However, it is important to note the role a populous and robust urban forest can play in preventing combined sewer overflow.

The root of this issue is the inability of these sewer systems to hold excess rainwater runoff. Many cities are incorporating green infrastructure strategies to significantly reduce runoff. Studies show urban forests can reduce annual stormwater runoff by 2-7%. Fully-grown trees can hold up to 100 gallons of water during storms. The U.S Forest Service estimates New York City trees prevent 890 million gallons of stormwater from entering the sewer annually. Green infrastructure is not only effective but it is much less costly then gray infrastructure improvements. Portland Oregon, a city that sees 37 inches of precipitation a year, has saved $64 million in costs annually.

---

million by switching to a green infrastructure plan which included the planting of 4,000 trees.\textsuperscript{30} Gray infrastructure only serves to reduce runoff, and therefore pales in comparison when ones examines the numerous additional benefits green infrastructure provides other than reduced stormwater runoff.

When wastewater is not discharged it can go through up to three treatment phases. ‘Primary treatment’ involves filtering and skimming water to removes large and small-suspended material. Secondary treatment utilizes bacteria to remove organic compounds. Secondary treatment does not remove eutrophication-causing phosphorous compounds; therefore tertiary treatment uses lime to remove these elements.\textsuperscript{31} This third treatment phase is very expensive and most U.S cities do not engage in this tertiary phase. As a result phosphorous filled wastewater is released into waterways and water bodies, resulting in environmentally damaging algae booms. In cities where underground aquifers are the main source of water, the pouring of this wastewater into stream stops this water from recharging groundwater.

Wastewater land disposal is an alternative to releasing first or secondary treated water into waterways. This process reuses wastewater on land to water vegetation. Using wastewater on vegetation recycles phosphorous compounds to support plant growth. Bacteria naturally found in the environment can consume complex organic compounds in the water. Soil can act as a natural filter of particles, smaller organic matter and microorganism allowing clean wastewater to reach and recharge ground water.\textsuperscript{32} The strong absorbency of trees makes them a great candidate for wastewater land disposal vegetation. This wastewater technique can be used to meet the water needs of city parks, and greenbelts. The urban forest is a destination for this

\begin{footnotesize}
\begin{itemize}
  \item \textsuperscript{30} Rosen, Mike. “Trees! Watershed Health and Urban Tree Protecting the Investment” \textit{Environmental Services City of Portland, National Green Infrastructure Conference.} (2011).
  \item \textsuperscript{31} Grey and Deneke, \textit{Urban}, 64
  \item \textsuperscript{32} Ibid., 66
\end{itemize}
\end{footnotesize}
problematic wastewater. By reducing the cost of wastewater treatment, more money can be allocated to updating gray and green infrastructure to prevent combined sewer overflow.

**Noise Abatement.** Cities are filled with noise: ground, air, and water transportation, construction, repair, and maintenance. Areas with higher population densities also have increased noise pollution. Noise pollution is detrimental to mental health and can increase the stress levels of a community. Sound attenuation, or the reduction in sound intensity, can be used to increase comfort. Trees and shrubs act as attenuators when they absorb sound energy. Plants are particularly efficient in absorbing distressing high frequency noises.\(^{33}\) Densely planted trees and shrubs can reduce urban noise by up to 5 dB. Trees and shrubs also mask sound by making noise when the wind rustles leaves. Generating pleasant noise allows humans to filter out irritating noise more easily.\(^{34}\)

**Air Pollution Abatement.** Air pollution is any chemical in the atmosphere whose concentration is high enough to damage organisms, ecosystems, human materials, or change the climate. These pollutants stem from both human and natural sources.\(^{35}\) Ecosystems have natural processes that reduce and remove pollutants through dilution, precipitation, filtration, and chemical reactions. However, when human activities produce contaminates at a rate that exceeds the ecosystems ability to remove them, contaminants become concentrated and harmful. The majority of human-made air pollutants are created in cities and therefore the residents of urban areas are exposed to the highest concentration of pollutants. Examining the chemistry of these pollutants will better help our understanding of how an urban forest ecosystems can combat air pollution.

---

\(^{33}\) Miller, *Urban Forestry: Planning and Managing Urban Greenspaces*, 72  
\(^{35}\) Miller and Spoolan. *Living in the Environment, 17e*, 468-471
**Particulate matter** is the suspension of extremely small droplets of a liquid (aerosol) or solid. Particulates range in size from 2.5-10 micrometers, allowing them to remain in the air for long periods of time. Human activities that engage in the burning of fossil fuels, such as the operation of automobiles, power plants, incinerators, and smelters, create 38% of particulates. The size of particulate matter allows it to penetrate deep into lungs and even into the bloodstream. Studies have shown exposure to particulate matter can cause nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and respiratory irritation such as coughing or difficulty breathing. Those with lung or heart disease, children, and the elderly are particular susceptible to particulates. Trees and other vegetation can remove particulate matter from the air through three means: sedimentation, impaction, and deposition. Sedimentation is the process through which particulates accumulate on the upper surfaces of trees. Trees significantly decrease wind velocity allowing gravity to pull large particulates onto upper tree surfaces. Impaction ensues when an air current approaches a tree, the current divides and the particle continues with forward momentum and impacts on a tree’s surface. Leaf petioles and fine hairs are extremely well suited for capturing particulate matter through impaction. The rate of impaction also increases when trees surfaces are wet. Deposition is the process by which precipitation finally washes particulates that have landed on trees surfaces into soil. Once in the soil, pollutants can be neutralized through chemical reactions and direct deposition.

**Nitrogen oxides and nitric acid** are pollutants which form under chemical reactions. Nitrogen and oxygen react to form Nitric oxide (NO) during high temperature combustion in

36 Ibid.
automobile engines, coal power plants, and industrial power plants. Nitric oxide is highly reactive and will form nitrous dioxide (NO$_2$) when it is exposed to oxygen. Nitric oxide and nitrous dioxide are collectively called nitrogen oxides. Short-term exposure (30 minutes to 24 hours) to nitrogen oxides can irritate the eyes, nose, and throat in healthy individuals and can aggravate asthma and bronchitis symptoms. Nitrogen oxides can react with sunlight and volatile organic compounds to form ozone, another air pollutant. Nitrogen oxides also react with ammonia, moisture, and other compounds to form particulate matter.$^{39}$ In addition, nitrous dioxide can react with water vapor to form nitric acid (HNO$_3$) and nitrate salts (NO$_3^-$), which contribute the acidification of streams and lakes and is also damaging to public health.$^{40}$ Tree leaves absorb these nitrogen oxides through stomata, where gas diffuses into intercellular space.$^{41}$ Sometimes this nitrogen is used by the trees for growth.$^{42}$

Two-thirds of the sulfur dioxide (SO$_2$) in the atmosphere is created through human activities. This colorless gas is created through the burning of coal in power and industrial plants as well as in oil refining and the smelting of sulfide metals. Once in the air sulfur dioxide can become sulfuric acid (H$_2$SO$_4$) and solid particles of sulfate salts (SO$_4^{2-}$). Sulfur dioxide, sulfuric acid, and sulfate salts are all extremely acidic and can cause major damage to environmental and human health. Their low pH’s can destroy soil microbes, harm vegetation, and threaten aquatic life.$^{43}$ These sulfur oxides also aggravate asthma and bronchitis. Trees also absorb these sulfur

---

$^{40}$ Miller and Spoolan. *Living in the Environment, 17e*, 468-471
$^{41}$ Nowak, J. David and John F. Dwyer, 28
$^{42}$ Miller, “Urban Forestry”, 67
$^{43}$ Miller and Spoolan. *Living in the Environment, 17e*, 468-471
dioxides through their leaves, utilizing some sulfur for growth. A study of 14 cities found that on average trees removed 199 tons of sulfur dioxide from urban air.  

*Carbon monoxide* (CO) is yet another air pollutant removed by trees. This gas is formed during incomplete combustion of carbon material, such during forest fires, the running of carbon-fueled power plants, and tobacco smoke. When inhaled, carbon monoxide reduces oxygen’s ability to bind to blood cells. This lack of oxygen can impair heart and lung function. Prolonged exposure to carbon monoxide can result in heart attacks and increased the severity of asthma and emphysema. In summer months, woody vegetation has shown to remove 1.2 tons of carbon monoxide a day.

Trees are particularly useful in the remove of ozone (O₃) from the atmosphere. This gas acts as a pollutant in the lower levels of the atmosphere and contributes to photochemical smog. Ozone exposure will exacerbate lung and heart diseases, increase the likelihood of contracting a cold or pneumonia, and harm the eyes, nose, and throat. Researches estimates trees could remove 10.8 tons of ozone in a single day.

Tree pollution removal studies show trees can remove pollutants by the tons. In New York City, trees removed 67 tons of carbon monoxide, 364 tons of nitrogen oxide, 536 tons of ozone, 354 ton of particulate matter (PM₁₀) and 199 tons of sulfur dioxide during nonprecipitation periods. Health and canopy cover are the most influential factors affecting the rate of air pollution removal. Tree species with high leaf circumference to area and surface to

---

44 Miller, “Urban Forestry”, 67-68
45 Miller and Spoolan. *Living in the Environment, 17e*, 468-471
46 Miller, “Urban Forestry”, 67
48 Miller “Urban Forestry”, 67
49 Nowak, J. David and John F. Dwyer, 30
volume are the most suited for removing particulate matter from air. Trees with high metabolic rates and resistance to drought are best suited for removal of gaseous pollutants.  

**Phytoremediation.** Vegetation, including trees, has shown to be effective at removing contaminates and pollutants from soil and water in brownfields, landfills, and contaminated sites. These plants absorb, chemically transform, and contain these hazardous contaminants, protecting environmental and human health.  

**Climate Change.** Trees are instrumental in mitigating the effects of climate change. Trees are extremely effective in storing large amounts of carbon dioxide. Large trees can store 3 tons of carbon dioxide, which is almost 1,000 times more carbon stored by younger trees. When in good health, trees will store additional amounts of carbon each year. This highlights the importance of having a well-managed urban forest, as trees can provide the highest amount of ecosystem services when they are healthy and mature. Within the continuous United States urban trees store a gross carbon sequestration of 22.8 million tons of carbon per year; this is equivalent to the amount of carbon the U.S produces in 5.5 months. To look at individual cities, Chicago’s urban trees gross sequestration of carbon is equivalent to the amount emitted within a week by the transportation system.  

Urban trees already provide a huge benefit to both the urban and global community by storing this carbon. Unfortunately the storage remains ignored and under utilized. If a city hopes to starve off the more detrimental effects of climate change they must have a vested increasing in decreasing the amount of carbon dioxide in the atmosphere.  

**Wildlife and Biodiversity.** Urban wildlife is a useful indicator of the health of the urban environment. Decline in wildlife population signal environmental problems that have gone on unnoticed.

---

50 Miller “Urban Forestry”, 68
51 Nowak, J. David and John F. Dwyer, 35
52 Ibid., 29
on unbeknownst to humans. This data can guide us to the discovery of problems which could have eventually snowballed and affected a wide variety of wildlife and vegetation as well as humans. Urban nature serves to increase the biodiversity where species were completely lacking previously. Urban dwellers appreciate interactions with wildlife. The bird feeding industry’s net worth of $170 to $517 million speaks lengths of the desire urban populations have to connect with wildlife. Movements within cities to increase urban nature allows for the further cultivation and restoration of greenspace, making urban areas particularly equipped to increase biodiversity and further reap the benefits of robust natural ecosystems.

When facing an impending danger it is important to utilize your best tools to combat it. If North American cities hope to improve their current maladies and mitigate the problems of the future, a strategy utilizing a healthy urban forest is a must. The proper management of an urban forest will provide the highest amount of benefits necessary to combat a growing population, tired infrastructure, failing air and water quality, eroded soil, high energy cost, heavy storms, and climate change.

Chapter 2: Finding Your Roots: Environmental History

To understanding the connection between the dichotomy of forest and city, we must examine the respective past of each. Seeing how these realms initially connected will demonstrated how they stand united today.

The Forest. Trees were tools of early civilizations. Though we have little information about their management, we can tell from records that that were specifically incorporated into landscape designs. In ancient Egypt from 1400-1362 B.C, royals went to great lengths to
transport sycamore, palm, and pomegranate trees over 1,000 miles into their gardens. Ramses III had trees placed along streets to create a more enjoyable experience when walking through the city. Ancient Greece also used trees to provide shade along crowded pathways and to enhance the beauty of their plazas. The Greeks are the first to document tree care techniques for transplanting and taking care of wounds. The great ancients such as the Chinese, Phoenicians, Persians, and Romans all understood trees could provide value for their cities. All used trees to improve the aesthetics of gardens, groves, temples, statues, and buildings.

We do not see the full utilization of trees by urbanized people until after the Middle Ages. During the Middle Ages most cities were within walls, leaving no room for gardens and open space, though forests surrounded cities and were easily accessed and used for festival and celebrations. Only during the Italian Renaissance do we see trees and green space intertwined with city living. The Renaissance highly valued nature for its aesthetic properties; they also viewed it as evidence of natural truth. As the Renaissance spread across Europe, so did the value of nature. As the centuries marched on, the aesthetic values of trees and green space were further incorporated through lawns, waterside promenades, gardens, avenues, squares, and plazas.

During this time trees were not only planted for aesthetics but as symbols of power and control. Having the ability to plant trees showed one’s social standing, the aristocracy were the only people wealthy enough to create gardens and lawns. City trees remained mostly private until the 1800s when gardens were open to some members of the public.
Using trees to improve the environment is a deep-rooted tradition in North America. Most histories of North American forestry start with tree care developments made in Europe throughout 16th and 19th century. Forestry, the science and practice of planting, caring, and managing forests, is seen mainly as a relatively recent creation. However, this telling leaves out the management of North American forests by Native Americans. Contrary to mainstream thought, Native American cultures had a heavy influence on the formation of current forests. These management practices not only helped these cultures meet their own needs but also helped care for the long-term health of the forest.

Early settlers, missionaries, trappers, and explorers documented Native Americans fire use. Forest management through fire use was a technique inland tribes used to alter forests and create savannas, reasons for these alterations varied region to region. Some tribes burned large areas of forest to drive large game into smaller advantageous hunting grounds. These fires would also allow for the collection of roasted insects, unguarded honey, and seeds. In addition, fire was used as a pruning tool to increase crop yields of camas and berries.\(^{58}\)

Fire was used to manage the ecology of forests through the creation of savannas which acted as ecotones. Ecotones are transitional areas between ecosystems with higher species population and densities than either of its adjacent ecosystems. The creation of savanna ecotones between forests and grasslands increased biodiversity within this transitional area.\(^{59}\) Increases in biodiversity also increase the efficiency of biological communities and their ability to provide stability for all populations using forest resources. Native American did not destroy entire forests or ecosystems. To control fires, Native Americans would set fire only during spring and fall near

\(^{58}\) Williams, Gerald W. (Summer 2000). "Introduction to Aboriginal Fire Use in North America" (PDF). Fire Management Today (USDA Forest Service) 60 (3): 8–12.

raining seasons to ensure they weren’t setting fire to dry wood. In fact, the systematic burning only destroyed downed wood and weak trees. By creating controlled fires, Native American decreased the amount of highly flammable woody debris on the forest floor, decreasing the likelihood of uncontrolled wildfires. Foresters believe these intentional burnings had a huge impact on the formation of today’s North American forests. Today, the U.S. Forest Service also uses controlled fires to prevent wildfires.

Arboriculture, the “planting, protection, and maintenance of trees and shrubs”, is one of the earliest essential fields that make up the rich perspectives of urban forestry. As a specialization within the field of horticulture, the growing of plants for consumption and aesthetic value, arboriculture is focused on the health of individual trees and their aesthetic value for landscapes.

Developments in tree care practices boomed in England between 1500 and 1800. Books published at this time detail proper pruning and fertilizing. The most impactfull book Sylva by John Evelyn was published in 1662 and offered the greatest expansion in tree care knowledge. For the first time a professional arborist gives instructions on species selection, pest and disease control, and innovative ways to transplant trees. It is also recommended by Evelyn that trees be planted along houses and streets to give people the impression they lived in a forest. In Europe, massive gardens required “estate forester” to care for the numerous trees on properties. The creation of the Society for the Improvement of Arboriculture in 1828 established arboriculture as a unique profession. A new impassioned generation of arborist conducted research that led to more comprehensive care of wounds, pruning, transplants, internal decay, disease, and pests.

60 Williams “Early Fire Use in Oregon”, 13-19
61 Williams “Introduction to Aboriginal Fire Use in North America”, 11
62 Gerhold, “Origins”, 10
63 Ibid., 11
The growth of North American forestry as we known it today, evolved through three major changes in the forestry community. Its beginnings come from English ‘classical forestry’. In the early 1900s, European silviculture practices begin to take hold in North America. New tree care information was only utilized on public lands. Public lands were mainly used for timber production, foresters were employed to maintain the land but they did not have a heavy influence on when timber should be planted or harvested. Private timber reserves did not employ forestry professionals. Mostly likely due to this reason, private timber lands were completely depleted by the end of World War II.\(^6^4\)

Lack of timber in North America launches forestry into its second phase, ‘economic forestry’. Post-World War II, untouched public lands were looked to restore America’s timber supply. Forestry became an economical analysis of resources focused on high timber and fuel wood yields as well a ‘satisfactory regeneration rate’. The stimulation of forestry management allowed for timber industry revival. Forestry developed major management plans and standard land practices.\(^6^5\)

Forestry’s emphasis on economy over environmental well-being caused public outcry in the 1960’s. The timber management policies of clear-cutting, or cutting of all trees in a certain area, was criticizes as an extremely intensive practice that destroys the habitats of wildlife, plants, bacteria, and insects, reduces flood absorbing buffer zones, contributes to soil erosion, and damages recreational possibilities and aesthetic value.\(^6^6\) This criticism became a national issue when the U.S. Forest Service began clear-cutting on steep slopes in the Montana Bitterroot National Forest. Clear-cutting on slopes is an especially damaging practice for it increases the

---

\(^6^4\) Miller, *Urban Forestry: Planning and Managing Urban Greenspaces*, 32  
\(^6^5\) Ibid.  
likelihood of erosion and landslides. Montana Senator Metcalf’s third party investigation denounced the U.S Forest Services practices as detrimental to the forest and people.  

Following several other disputes over forestry’s emphasis on timber profits, forestry entered into its current phase of ‘ecosystem management’. This converted forestry to a multiple-use management field, overseeing timber and fuel wood production, biodiversity, wildlife habitats, watershed protection, aesthetics, soil protection, and recreation. An ecological approach gave forestry a new mission to responsibly sustain forests and their surrounding ecosystems.

The forestry community’s ability to respond to and combat environmental issues for rural residents, demonstrated forestry also had much to offer to urban areas suffering from environmental issues. A new branch of forestry called environmental forestry (which would eventually be renamed urban forestry) focused on the ability of trees to provide physical and social benefits for humans. The forestry community realized that not only could environmental forestry help urban people but also it could be used as tool for the survival of forestry at large. Urban acceptance and support for forestry is essential to its long-term existence. Not only will urban areas expand but urban populations hold more political power than suburban and rural populations combined. If forestry hopes to continue to receive federal money, continue its timber production, and keep ecosystem thriving they will need the urban public to understand trees are important for the environment, economy, and mental and physical well-being.

Despite the long history of planting and managing trees in cities, urban forestry does not become a recognized branch within forestry until the 1970s. In June of 1967, the Citizens Committee on Recreational and Natural Beauty recommends to president Lyndon B. Johnson an

---

68 Miller, _Urban Forestry: Planning and Managing Urban Greenspaces_, 32
69 Ibid.
‘urban and community’ forest program aimed at “providing technical assistance, training, and research” be created within the U.S. Forest Service. In response, the Pinchot Institute for Environmental Forestry Studies was established in 1970 within the U.S. Forest Service. The Pinchot Institute defined environmental forestry as:

Environmental forestry involves those aspects of resource management dealing with man’s need for, and association with, tangible and intangible values of forest vegetation in and around metropolitan areas. Such forest vegetation involves a wide range of forested conditions-ranging from city park environments to greenbelts and woodlands in the rural areas that intersperse the huge, sprawling, urban complexes throughout Megalopolis.

Following its establishment the Pinchot Institute (later renamed Consortium for Environmental Forestry Research) has become a leader in this field.

**Urban Forestry Legislation: 1972 Urban Forestry Act.** This act was an amendment to the Cooperative Forestry Assistance Act of 1950. The Secretary of Agriculture is authorized to create plans with State foresters detailing how technical assistance to private landowners, forest operators, wood processors, public agencies would be provided to encourage “multiple-use management and environmental protection and improvement of forest lands, the harvesting, marketing, processing of forest products, and the protection, improvement, and establishment of trees and shrubs in urban areas, communities and open spaces.” This act emphasized foresters bringing private agencies into the planning, in order to better utilize their services. Following the passing of this act, 7 states created provision for urban forestry programs within their forestry laws. However state action is not unilateral, without funding or illustration of why urban

---

70 Miller, *Urban Forestry: Planning and Managing Urban Greenspaces*, 33
72 Miller, *Urban Forestry: Planning and Managing Urban Greenspaces*, 33
73 Grey and Deneke, *Urban, 7*
forestry provides ecological, economic, and social benefit for cities, urban forestry programs remain in concentrated areas.

**1978 Cooperative Forestry Assistance Act.** The first time federal funding is allocated to urban forestry is in 1978. This act provides $3.5 million to state forestry agencies. With this funding state forestry agencies provided cooperative financial and technical assistance to local government, public agencies, educational institutions, organizations, associations, and individuals. This 1978 act was a further amendment to the Cooperative Forestry Assistance Act of 1950 and was seen as an improvement between state and federal relations. Giving states the authority and funding for their own urban forestry programs allowed for state foresters to have more control over how programs would be presented to the public. Funding from this legislation slowly dwindled each year, in 1984 only $1.5 million was allocating toward its budget.

**1990 Farm Bill.** The Farm Bill provided further amendments to the Cooperative Forestry Assistance Act and marks a huge step forward in urban forestry. This bill allowed the U.S. Forest Service to better serve the needs of states through overseeing more grants and further technical assistance. The goals of this assistance were to increase public awareness of urban tree cover benefits, motivate private property owners to plant and maintain healthy trees, and educate and assist grant recipients in managing local urban forest as well as identifying what areas can use more trees and what species can thrive there. In addition, the bill also aimed to create tree planting programs to increase the ecology benefits of city trees as well as the creation of demonstration projects that would showcase the benefits of tree cover in cities.

---

74 United States Department of Agriculture “An assessment of the forest and range land situation in the United States” (January 1990), 561
75 Pinchot Institute for Conservation “Allocating Cooperative Forestry Funds to the States: Block Grants and Alternatives: A Report to the US Forest Service”, 8
76 Miller, *Urban Forestry: Planning and Managing Urban Greenspaces*, 34
Through each of these goals, foresters were to impart the latest skills and arboricultural practices (such as the cultivation of trees, shrubs, and complementary ground covers) on those involved in planning, development, and maintenance. However, the sharing of knowledge to tree care professional and volunteers was a concentrated approach, integrated into programs where it was seen fit. The bill also held the goal of broadening research and education surrounding tree/forest science and maintenance, the values of combining tree and ground cover plants in the urban landscape, the economic, environmental, social and psychological benefits of urban forest, and the ability of trees to conserve energy and mitigate urban heat island effects. The bill provided financial assistance through means of matching grants to local government, nonprofits, and local community groups who take on urban forestry projects\textsuperscript{77}. It also significantly increases the provisions in this act from $2.7 million to $30 million. In order for states to qualify for grants and assistance they needed to appoint a urban forestry coordinator for the state as well as create a state urban forestry and advisory council.\textsuperscript{78}

The Farm Bill also creates the National Urban and Community Forestry Advisory Council. This 15-member council is made up of members representing forestry nonprofits, private forestry industry, state government, local government, urban forestry consultants, academics, state forestry agents, professional arboriculture, Extension Service, Forest Service, and residents of communities active in urban forestry. This council is to create a national urban forestry action plan every 10 years which details the state of urban forestry programs and research, reviews the efforts of government and organization working on urban forestry issues, and make recommendations on how these efforts can be improved to raise the status of urban

\textsuperscript{77} Farm Bill “Public Law 101-624”. Nov 28 1990, p 104-STAT. 3534
\textsuperscript{78} Miller, Urban Forestry: Planning and Managing Urban Greenspaces, 34
forest. The Council will also provide criteria to evaluate programs applying to for funding through the matching-fund.\textsuperscript{79}

**Forestry Organizations.** Non-governmental groups played a vital role in the progress of urban forestry. As the idea of urban forestry management was developing there was disagreement within the forestry community whether urban forestry was a discipline within forestry. As demonstrated earlier, the forestry profession evolved from concerns for timber production and sustainable ecosystem management. To many foresters urban forestry’s goals were mostly anthropocentric and therefore not apart of forestry’s own mission. They saw urban forestry’s promise was a benefit to urban people, not the to land and forest. To these foresters, city planners and urban community organizations, who would reap the benefits of urban forests, should be responsible for organizing, implementing, and managing urban trees. Reduced federal budgets to the U.S. Forest Service in the late 1970s and early 1980s further lowered the priority of urban forestry. Until the 1990s the U.S. Forest Service’s obligations to urban forestry was marked by language such as ‘limited assistance’, ‘limited training’, and ‘limited co-sponsorship of projects’.\textsuperscript{80} Instead the U.S. Forest Service urged non-profits such as the American Forest Association to take the lead on bringing forest to the urban setting.

**1924.** Shade Tree Conference in 1924 is the first gathering of arborist in America. At the conference, latest methods of tree care are discussed, such as practical tree pruning, healing, insect and disease abatement, and surgery. It is at this conference that the unique problems facing municipal shade trees are discussed. In the 1930s Dutch Elm disease is discovered in North America. The disease spreads from New York City to the Midwest, killing over 6 million trees. Organized arborist argued lack of tree management programs in cities and suburbs allowed for

\textsuperscript{79} Farm Bill “Public Law 101-624”. Nov 28 1990, p104-STAT. 3538
\textsuperscript{80} Grey and Deneke, *Urban*, 10
this disease to become widespread. The International Shade Tree conference eventually becomes the International Society of Arboriculture in 1975. In 1924, the conference only had 36 members, as the group spread and increased knowledge of arboriculture across the U.S membership rose to over 14,000 in 2001.  

1972. Society of American Foresters, a professional forestry nonprofit, created the Urban Forestry Working Group. This group defined its purpose as the cultivation and management of trees for the physiological, sociological, economical benefit of urban population. They aim to bring about these benefits using a multi-managerial approach of the watershed, wildlife habitat, outdoor recreation, landscape, recycling of municipal waste, tree care, and the future production of wood fiber. By 1980, the Urban Forestry Working group has over 700 members. The Group releases a ‘white paper document’ stating urban forestry is a essential part of resource management. The group sets out to assist urban foresters’ education of the public. They also recognizes professionals other than foresters, such as commercial arborist, consultants, landscape architects, commercial nurseries, and tree care firms must be involved in these program and should be reached out to for better involvement. They also reminded the forestry community that urban residents have a strong political influence on resource issues in both rural and urban areas. Stating the best to way to showcase why urban people should care about rural resource management is to illustrate the benefits of trees on their own turf.

1973. The International Society of Agriculture forms the Urban Forestry Committee and starts the “Journal of Arboriculture.”

---

81 Gerhold, “Origins”, 13-14
82 Grey and Deneke, Urban, 8
83 Ibid.
1978. The first National Urban Forestry Conference is held in 1978 through the sponsorship of the U.S. Forest Service and State University of NY of Environmental Science and Forestry. This conference provided connections between that all the players involved in urban forestry. The session discussed the benefits trees provide to urban society as well as the protection and management of city trees.\(^8^4\)

1980. This year the U.S. Forest Service and the American Forestry Association meet. During this meeting, the U.S. Forest Service encourages the American Forestry Association to take up the reigns on the urban forestry movement. The American Forestry Association decides to target policy makers and exhibit the benefits a urban forest can bring to their cities.

1981. The American Forestry Association forms The National Urban and Community Forestry Leaders Council. The council was to be a base for the urban and community forestry movement. The use of ‘community’ in urban and community forestry was included to appeal to both cities and suburbs. The American Forestry Association wants better management of trees whenever people live, including towns and villages. Also, the Association felt the broader application of the word ‘community’ would make legislators more likely to get on board.\(^8^5\)

The City. During the 18th century there was rapid development in production technology. One of the first industry’s to experience these advancements was the British agricultural sector. Developments in crop rotation, improvements of the plough and seed drill, better infrastructure, and selective breeding increased the output and profitability of farms. The increase in food supply allowed for populations throughout England to increase. The enclosing of property also combined small farms into larger ones. These developments allowed for farms to increase production while decreasing their demand for labor. Rural labor fled to cities, further increasing

\(^8^4\) Ibid., 9
\(^8^5\) Ibid., 10
the urban population. This increase in urban labor allowed for the greater Industrial Revolution to take course. However, the ability of cities to provide tolerable amenities could not keep up with the pace of population growth, leading to overcrowding and pollution.86

The Industrial Revolution took hold in America about 100 years after England’s initial progress. In 1850, less than 20% of the American population lived in urban areas. In 1920, 50% of Americans lived in urban areas; more currently in 2010 80% of the population lived in these areas.87 The development of cities initially depended on the availability of transportation. During the early American settlement period water was the main form of transportation, thus towns were founded along ports and waterways. These new cities were very small, with stores and homes a walk or horse ride away. Residents of these settlements were never far from wilderness. As the Industrial Revolution was brought over to America it disadvantages came with it. The overcrowding and pollution became burdensome for the upper class that used railroad and trolleys to escape to suburban oases.88

In the 1920s a desire for the pleasantries of the suburbs created the first era of suburban sprawl. A trolley’s ride away from the city, suburbs offered the middle class single-family dwellings with more open space. Before the sprawl, suburbs were relatively compact with most residents only a short walk from transportation.89 The availability of automobiles accelerated the growth of suburbs. No longer chained to mass transportation, the middle class could navigate throughout suburban areas. Suburbs grew, leading to the development of land in between cites and suburbs as well as the untouched land beyond their borders. Access to personal transportation grew, causing less and less people to utilize mass transit for their morning

86 Miller, Urban Forestry: Planning and Managing Urban Greenspaces, 8
88 Miller, Urban Forestry: Planning and Managing Urban Greenspaces, 9
89 Ibid.
commutes into cities. This attraction to personal transportation led to a traffic congestions crisis in the 1950s.\textsuperscript{90}

Cities across the U.S struggled to combat the clogging of their streets. Cities had less money to address this problem now that much of the wealth in their cities had moved to the suburbs. Fearing this congestion would slow down economic growth even further municipalities reached out to the federal government. It is important to note these municipalities did not believe too many cars caused the traffic, they felt their roads and infrastructure were crumbling and inadequately handling traffic.\textsuperscript{91} Therefore, when Congress passed the Federal Highway Act of 1956, a plan to a create an interstate highway system, Congress members representing urban district urged for these new highways to extend into cities. Regrettably, these highways only further exacerbated the plight of cities.

Creating easier access between cities and suburbs encouraged more people to flee to the suburbs. This time was know as the era of white flight, as low-income minority groups moved into city centers, racially prejudiced middle class whites moved to more homogeneous suburbs. Highways brought commuters directly to city centers, bypassing entire neighborhoods. This economic isolation destroyed many neighborhoods leading them into decline. Racist zoning practices that held the interest of white property owners above those of minority property owners kept these minorities from purchasing land within suburbs. The departure of the middle class left cities with destabilized economies and also deflated government income from property taxes. Cities throughout the U.S. fell into decay while suburbs thrived.\textsuperscript{92}

\textsuperscript{90} Ibid., 11
\textsuperscript{92} Miller, Urban Forestry: Planning and Managing Urban Greenspaces, 11
The American economy boomed throughout the 1950s and 1960s. As household income rose, land ownership increased while population density was kept low. During this time land use growth was drastically faster than population increases. For example, in Springfield Massachusetts from 1956 to 1965 population grew 18%, while land use increased 136%. This trend caused suburbs to grow and expand their borders, while losing open space. In the high time of the automobile, only upper middle class areas had access to outdoor recreation while urban centers were effectively cut off from nature.93

The 1960s and 70s were all-time lows for cities. Depopulation, pollution, unemployment, crime, high noise levels, and inadequate transportation plagued the U.S. city. Without middle and upper class citizens, municipal governments had shrinking budgets that left them unable to solve the issues facing their cities. The obvious racial preference for whites by local and federal governments led to riots that further destroyed the infrastructure and economies of urban areas.94

Shortsighted attempts were made to save the American city. Federal programs funded improvements to housing and commercial zones. This involved the tearing down of low-income housing projects and selling the land to developers at a reduced price.95 Developers would then turn these properties into neighborhoods that would attract wealthier residents. Unfortunately, this forced removal caused the low-income populations to congregate. Creating communities with high poverty rates only served to increase the blight of the poor.96

For most of the 1980s and 1990s nonurban areas saw population rises. The technological revolution created a shift in the economy to white-collar jobs. Companies no longer needed to be in major cities, with most making the move to small cities.

93 Ibid., 12
94 Ibid.
96 Miller, Urban Forestry: Planning and Managing Urban Greenspaces, 12
In 1990s, the ideas of Jane Jacobs, urban planner and author of *The Death and Life of Great American Cities*, become very popular. Jacobs advocates that cities need diverse land use, walkable city streets, and high densities to promote economic and social capital. During this time the field of urban planning and public health begin to work together to champion the physical and mental health benefits of mixed-use zoning. Due to this partnership, many U.S. cities now use green infrastructure to create livable cities. Focusing on well-being to create growth has been a hallmark of the past decade of urban history.

**Chapter 3: Economic Analysis**

**Ecological Economics.** Ecological economics is an important school of thought that argues traditional economics has made a fundamental misjudgment that will cause catastrophic side effects. Traditional economics weighs natural capital (ecosystem services) equally to human capital (technology and labor). This view would hold the labor of individuals interchangeable with the removal of air pollutants by a tree. However this viewpoint is flawed, human labor or technology can not replace or attempt to replicate the services of trees. As illustrated in previous chapters, trees provide numerous ecosystem services, all of which are essential for healthy and productive human populations. The ability of trees to turn carbon dioxide into oxygen provides a telling perspective of this flaw. Humans do not have the ability to turn large amounts of carbon dioxide into oxygen to keep the global population breathing. Human technology can not replace all of the ecological services provided by trees. The benefits of ecosystems are not additional resources for economic growth but the fundamental building blocks of an economy. Ecological economics argues a greater value, a monetary value, needs to be placed on trees not only for their services but for the necessary role they play in the biogeochemical cycles which sustain all life.

---

97 Lopez, 38-39
External costs created by those who will not bear the burden of these costs are sources for major environmental issues, such as natural resource depletion and climate change. A heavier emphasis on long-term sustainability for natural resources would deter the creation of externalities.

**Economic Benefits.** Urban forestry provides many social and economic benefits to individuals and communities. Benefits range from aesthetics to public health, these assets occur daily in communities but hard are to quantify. Trees increase the aesthetic quality of streets, parks, highways and buildings. Culturally we find vegetation appealing and this perception causes additional benefits to be reaped by individuals. When individuals are in aesthetically pleasing areas they feel a greater sense of safety. When in nature, especially beautiful places of nature, people create emotional and spiritual attachments to areas. This attachment and positive perception can produce economic benefit, encouraging people to move to or continue living in a neighborhood. Tree planting and monitoring projects are a huge part of urban forestry. These projects are vehicles to introduce more trees into an area while also engaging community members on the benefits of trees and well as tree care practices. Community involvement produces valuable tree inventory data and cultivates community concerned about the well-being of trees in their area. The presence of local tree projects creates a strong sense of community and empowerment. Active involvement in tree planting has shown to increase social identity and self-esteem in a community. These side effects of local tree projects contribute to social capital. Lopez defines social capital as “the strength and capacity of a network of human interactions and the associations with that network.” Studying social capital is a useful method to discern health and economic patterns with a community. A healthy urban forest supported by the involvement of community members increases social capital, influencing perception of one’s own community

---

98 Nowak, J. David and John F. Dwyer, 37
99 Lopez, 228
as well as creating stronger social ties among neighbors. An increase in social capital can increase trust, reciprocity, culture, social support, and cooperation within a community, promoting economic growth.\textsuperscript{100}

Urban forestry can also provide psychological health benefits for communities, increasing well-being and decreasing public healthcare cost. The psychological benefit of trees is extremely powerful. Studies have shown viewing trees from a window can significantly increase job satisfaction and increase well-being. The presence of trees in urban settings can reduce stress, improve learning and behavior in children, and improve physical health. Trees provide an oasis of privacy and an area of contemplation, thus changing mood and reducing stress. One study has shown hospital patients with window views of trees recover significantly faster and with fewer complications than those without tree views.\textsuperscript{101}

The physical benefits of trees can also relieve public health cost. The urban heat island effect can dramatically increase the temperatures within city limits due to widespread use of materials with poor thermal storage. As climate changes causes global temperature to rise and increases the frequency of heat waves, summer temperatures are expected to become extremely high. As explained previously, trees evapotranspire, introducing water vapor into the air considerably decreasing temperatures. This reduction prevents heatstroke, heat exhaustion, and heat cramps. Abatement of the urban heat island effect greatly benefits the elderly, infants, children, and citizens with chronic medical conditions. The shade provided by the urban canopy also reduces ultraviolet radiation exposure and reduces exposure health issues such as cataracts and skin cancer.\textsuperscript{102} Better air quality enhances public heart and lung health. Reduced stress levels

\textsuperscript{101} Nowak, J. David and John F. Dwyer, 37
\textsuperscript{102} Ibid.
are also shown to lower instances of interpersonal conflict and crime rates. Lastly, trees invite exercise through well-landscaped parks and tree lined streets and trails. Urban forestry programs cause volunteers to partake in long walks and moderate exercise during tree planting and monitoring. Communities engaged in exercise have lower rates of obesity, heart disease, and high blood pressure. Trees can decrease public health due to pollen allergies. However, the many benefits of urban trees can help reduce the occurrences of the most common and serious illness a health system can face. This net benefit increases the well-being of a city and provides a healthcare system an increase in cost savings.

Trees can bolster a local economy through increasing consumer spending and job creation. Business districts greatly benefit from tree-lined streets. The Journal of Forestry has found shoppers are willing to travel farther and longer to shop in districts with aesthetically pleasing trees. Shoppers have taken extra time to travel to these places causing them to spend more time there. Visitors to these green streets are shown to spend 9% to 12% more for products. In 2009 California’s urban forests supported 60,067 jobs. This employment provided $3.3 billion in individual income, yielding $826 million in local, state, and federal taxes. The urban forestry industry is a multifaceted tool, not only decreasing public health cost but also bolstering business districts and providing economic means for residents.

Vegetative landscapes also contribute to real estate values. Well-maintained trees on private property increase property values up to 20%, with an average increase of 5% to 10%. Homeowners also benefit from urban trees through deceased heating and cooling cost. Studies

103 Ibid.
106 Grey and Deneke, 60
looking at the value trees can contribute to real estate prices have cast a wide net of the actual value trees can bring to homeowners. Values vary due to differences between regions, developers, buyers, and sellers, but all studies indicate there is economic value to having trees on property.

An urban forest also reduces infrastructure costs for cities. Shade trees are shown to reduce the need for road maintenance repair. A study found when 20% of a street was shaded, a pavement’s condition could be enhanced by 11%; this enhancement yields a 60% savings on resurfacing over the course of 30 years. In Modesto, California, shade trees reduced maintenance cost by $7.13/m² over a 30-year period. The urban forest’s reduction of stormwater runoff also reduces municipal maintenance cost. In New York City, street trees intercept 890 million gallons of stormwater runoff each year, averaging out to 1,525 gallons of water per tree; this service has an estimated value of $35 million. Monitoring and maintaining urban trees will ensure these savings are continued.

Urban forestry can also be a valuable form of environmental education. Integrative urban forestry programs heavily rely on community volunteers. Engaging community members teaches people of all ages the important of trees as well as their role in ecosystems. An urban forest is a great platform to engage people in environmental issues. A local urban forest program can also become a platform for low-cost activities for students. Showing school children how the field of environmental science and policy affect them at a young age can propel children toward a desired career path. Urban forestry programs also provide valuable job skills for volunteers and interns. These programs can teach organizational, time management, leadership, public speaking,

108 Ibid.
109 Ibid.
adaptability, and group work skills. It is in the best interest of communities to have residents with strong resumes, giving residents a higher likelihood of being hired and increasing their ability to bring capital into their communities.

**Benefit-Cost Analysis.** There is a variety of ways to assign monetary value to trees. These varieties try to combine and evaluate complex interactions trees have with their environments, making precise values difficult to determine. Trees can be assessed for their maintenance (planting, feeding, pruning, etc.), timber, property, insurance, tax deduction, litigation, and condemnation values. Most of these assessments rely on a compensatory value based off of the Council of Tree and Landscape Appraiser formula. To municipalities, this compensatory value would show how they should be compensated for the loss their urban forest and views trees as a structural asset. This formula uses a tree’s species, location, age, and condition to assess value. Each of these variables has a large impact on net benefit a tree can provide. For example, a tree’s location can provide health benefits, increased energy savings, and property value for one resident while also blocking another resident’s ability to receive solar heating through windows during the winter or grow a garden. Management of trees in public spaces is interlaced with management of other urban infrastructure operations, such as park and recreation programs, streets and roads, utilities, and urban planning.

The compensatory value of the loss of the urban forest to Asian long-horned beetle, an invasive species, is estimated at $2.3 billion for New York City and $669 billion nationally.110 The Asian long-horned beetle can infest a wide variety of trees common in cities and is capable of destroying 30.3% of urban forests.111 Asian long-horned beetles tunnel through trees feasting

110 Nowak, J. David and John F. Dwyer, 39
on vital woody tissue responsible for tree growth and carrying water and nutrients to leaves.\textsuperscript{112}

This beetle mates throughout the summer and fall and can fly over 400 yards making them highly dangerous to all forest ecosystems. The best way to prevent infestation is tree health monitoring. Tree health monitoring programs provide early detection and prevent the spread of invasives by routinely inspecting trees for symptoms of pest infestation and disease. To harvest the greatest net benefit from an urban forest decisive planning, design, and management of tree species, location, age, and condition is essential.\textsuperscript{113}

In contrast to a structural assessment, a functional assessment would assess the value of the positive and negative functions of trees. Positive values for trees would include ecological, health, and economic benefits. Negative values for trees include maintenance cost required to preserve tree health and protect human safety.\textsuperscript{114} These maintenance cost are required to improve the positive functions of trees and prevent costs of tree damage and removal. Yet again, in order to increase functional value robust management is needed to strengthen tree benefits and mitigate tree harm.

**Chapter 4: Politics and Administration of Urban Forestry Programs**

Urban forestry programs exist in many varieties and can be run by different organizations, use different methods, and have different goals. These programs can be run by local, state, federal, or non-profit entities. The goal of local urban forestry programs is to plant, maintain, and remove trees in their area. State programs are aimed to assist these local efforts


\textsuperscript{113} Nowak, J. David and John F. Dwyer, 41

\textsuperscript{114} Ibid., 39
while federal programs hope to assist both state and local programs to bring about a healthy and stable urban tree population across the country.\textsuperscript{115}

As of 2011, 58\% of U.S. communities do not manage their tree populations. This signifies a need to improve urban forestry programs at local levels.\textsuperscript{116} The number of urban forestry programs continues to grow each year so it is important as these programs are created coordinators understand the challenges and successes of established programs. An urban area’s level of urban forestry activity can be differentiated by U.S. Forest Service’s Performance Measures and Accountability System (PMAS) data. This method ranks urban communities based on their level of urban forestry activity from project (lowest ranking), formative, developmental, and sustained (highest ranking). Project level communities are solely dedicated to short-term projects, such as celebrating Arbor Day, planting trees, and applying for grants. This level is not involved in creating long-term programs aimed at preserving, cultivating, and caring for trees within their urban environment. Formative ranking areas establish trees and urban green spaces as assets of their urban community. Community-based programs are run with the help of technical and financial assistance, these programs are interested in caring for their urban trees either by engaging with community leaders, carrying out basic assessments of urban trees, or forming community committees. A developmental urban area will have already established community-based programs and is extending their scope of activity through using technical assistance to better train volunteers. These organizations take part in “planning, policy and budget development, meetings, workshops, urban natural resource inventories,..., management plan development, review of policies related to land use and development, and engagement in


\textsuperscript{116} Ibid.
partnership development”. \textsuperscript{117} Finally sustained activity cities are multi-tiered high functioning programs. These programs perform “annual planning, community leadership, and systematic approaches to conservation and the management of trees, forest, and related natural resources”. \textsuperscript{118}

Urban forestry programs are not unified by one authoritative entity. These programs are carried out through a combination of assistance sources. Also, there is no authority that guides urban forestry policy and methods. Each state has a U.S. Forest Service appointed urban forestry coordinator. This coordinator is responsible for the delivery of U.S. Forest Service assistance to local programs, documenting local assistance, and reporting outcomes of these programs. This coordinator can be helpful in guiding local programs to best practices. However coordinators may be spread thin and may find engaging and reaching out to all local programs difficult. Local programs face individual problems and limitations and must gather recommendations from coordinators, researchers, federal agencies, professional arborists, consultants, and other urban forestry programs to solve their unique problems. This sea of information can sometimes cause new findings and innovative practices to become lost and under utilized.

Urban forestry programs are mostly funded by grants and partnerships. State forestry programs are a large source of funding for local urban forestry programs, therefore understanding where state urban forestry programs receive funding from is key to learning how local programs can be enhanced. State and federal funding provide for 90\% of state urban forestry programs. State urban forestry programs mostly rely on federal funding, only 39\% of states use state funded grants while 83\% of states use federally funded grants.\textsuperscript{119} State programs

\textsuperscript{117} Ibid., 159
\textsuperscript{118} Ibid.
\textsuperscript{119} Ibid., 156
also receive money from their state’s general fund. Federal grants mainly come from the U.S Forest Service, Environmental Protection Agency, and Department of Transportation. State grants are created by dedicated budget allocations, state government general funds, and foundation/trust funds. Local forestry programs can also source their funding from non-states sources. These sources include a municipality’s general fund, federal, state, and local governmental grants, corporate and private grants, taxes, special benefit assessment districts, tree work permit and inspection fees, carbon trading, the sale of municipal wood products, and corporate sponsorship.

Local urban forestry programs realize the goals of urban forestry through planting, maintaining, managing, and promoting trees. This important level of urban forestry is in need of improvement. Between 1997 and 2002 there was no significant change in the total number of communities with urban forestry programs. However in the same time period, activity levels in already established urban programs increased by 33%. To breakdown this activity increase by PMAS ranking, there was significant increases in project, developmental, and sustained activity. Understanding how much and what kind of activity is happening in local communities can help policy makers and legislators focus assistance on areas in need of help.

The personnel that make up an urban forestry program are a collection of different skills sets and motivations. Foresters, arborist, landscapers, administrators, and consultants often run and manage these programs. Field work including, inventories, monitoring, public outreach, etc.,

---


can be done by full/part-time staff, college interns, and volunteers. Citizen science, or the use of nonprofessional volunteers to collect scientific data has become increasing popular in ecological monitoring disciplines, especially ornithology. Using unpaid citizen scientist cuts costs and increases staff. Studies show productive training of citizen scientist can produce “mostly accurate” urban tree inventories at lower cost than professional arborist.¹²³

As previously stated, urban forestry activity is increasing within established programs. One study examines the attributes of state urban forestry programs to determine if certain attributes are related to this increase. The study looked at variables such as technical assistance frequency, financial assistance, technical assistance, federal grants, state grants, federal money, and state money. They found technical assistance to be the strongest factor in increasing local urban forestry activity. More than 70% of the time technical assistance resulted in increased activity.¹²⁴ Technical assistance can be recommendations, information, and training related to tree cultivation, maintenance, and management. Financial assistance (through mostly state and federal grants) is also an increasing factor, however it is not as strong an attribute as technical assistance.¹²⁵ Technical assistance allows a program to build contacts and gain valuable information that fortifies its structure, enabling it to provide useful data for long-term planning.

Examining common challenges of strong urban forestry programs is important in identifying what is holding back programs from moving up in ranking. A study of the International Society of Arboriculture looked into the struggles of urban forestry programs practicing urban tree monitoring. Urban tree monitoring is the systematic collection of data from

---

¹²⁵ Ibid.
the same group of trees over time. Ideally, this is done to a wide cross-section of urban trees in order to gauge trends in urban tree health, such as tree mortality, growth, and longevity. Tree monitoring is important for urban forestry programs in order for them to create more effective and efficient management programs and to determine the influence of tree plantings. Monitoring and tree inventories both allow programs to know the number of trees in their forest, calculate ecosystem services, and learn tree maintenance issues, however inventories only provide a snapshot of this information and can quickly become outdated.

When looking at programs’ purpose for carrying out urban tree health monitoring the study found most urban forestry programs intend to use the data to track tree survival, health, growth, and measure performance progress. 44% wanted to have a proactive approach to caring for urban trees. Only 21% of programs aimed to use monitoring to educate and engage volunteers and community members. Lastly, 25% of participants were required to conduct urban tree health monitoring due to grant obligations. 126

Results showed the biggest challenge to a program’s tree monitoring was resources limitations (63%). Theses resources included lack of staff time to carry out monitoring and lack of dedicated funding. Other problems programs faced were data management and technology issues (47%), developing protocols (28%), and field crew recruitment (25%). 127

Researchers also asked program practitioners to give advice to other urban forestry programs who were in the process of creating a monitoring program. Practitioners most often said they would tell other practitioners to plan in advance their methods, data collection, and goals. Practitioners were also asked to give researchers advice on what research could help them

127 Ibid., 294
meet monitoring goals. Responses asked researchers to determine the best practices for monitoring and to create a standard protocol for urban forestry programs.\textsuperscript{128}

**Chapter 5: Policy Recommendations: Everything is Going to be Oakay**

A multidimensional asset with a guaranteed return on investment is an obvious and necessary decision every U.S. city should make. Urban forestry can give so much to urban communities, urban individuals, and the global community. Climate change and its disastrous side effects are a national security issue that should concern every municipal leader. If the modern city hopes to combat its current issues they must understand climate change and its ramifications will only exacerbate their municipal problems. Urban trees are an amazing tool capable of fighting environmental crisis, improving city life, cutting municipal costs, and making people healthier and happier. Urban forestry can solve issues facing our cities while also creating unique and important benefits.

As evident from studies examining the characteristics that make for a thriving urban forestry program, technical assistance is fundamental. Technical assistance allows for programs to grow in quality. Expertise given by accomplished foresters, arborist, coordinators, and other knowledgeable players takes years, time, and money to be constructed. This valuable knowledge prevents urban forestry programs from wasting time and energy pursuing unfruitful paths. The insight and skills of these experts makes for a well-rounded program. Policy should aim to increase technical assistance to these programs. One way of increase technical assistance is increase the amount of urban forestry coordinators per state. The U.S. Forest Service has a rich network of assistance that can be better spread to local communities. Hiring more urban forestry coordinators allows individual coordinators to narrow their focus on certain regions. This

\textsuperscript{128} Ibid., 295
concentration allows information and assistance to be reachable and readily available. A regional urban forestry coordinator can also be a bridge through which local programs can connect and collaborate through. This idea of collaboration and sharing is another way to increase technical assistance need. An online network of information, research findings, and recommendations should be created to connect all urban forestry programs. This network equips programs with the knowledge and contacts needed to make decisions distinct to their program. Combining the work of researchers, professionals, and coordinators also allow for communication between these forestry representatives. Communication can push researchers toward helpful research questions, highlight unseen challenges of programs, and allow for collaboration and partnership on trouble issues. Local arborist associations and landscaping companies can be approached about sharing their knowledge with local programs. Heightening interesting in urban trees is a way local programs and these organizations can ensure sustainable growth of their respective organizations.

My research has shown grants from all sources to be helpful in program activity growth. As previously mentioned, programs often are obligated to fulfill certain urban tree care practices when accepting grants. Government grants should begin to tie urban tree health monitoring to grant obligation to promote this integral practice.\(^{129}\) Local and state programs should also reach out to groups who benefit from urban trees as a possible source of funding. Tree programs spread awareness by teaching residents tree care is needed to ensure healthy long living trees. Educating residents promotes the sale tree care products and professional tree care services. State and local programs should explain the economic benefit urban forestry programs bring to material suppliers and tree care professionals. Business district organizations can also be reached out to

\(^{129}\) Ibid.
due to the increase capital they receive from healthy urban trees. Pitching funding urban forestry programs as a wise investment, capable of growing their businesses and spreading awareness of their brands through sponsorship is a great way to create additional funding for urban forestry programs.

Urban communities stand to gain the most benefits from a healthy forest. They are also instrumental players in strengthening urban forest health. Residents have easy access to trees in their neighborhoods and are the only ones who can care for trees on their own properties. Concerned residents can be central in quickly responding to tree damage and identify invasive insects and diseases. Having an educated urban community is essential to an integrated program. Federal, state, and local urban tree programs need to incorporate education and awareness goals into their mission statements. Having urban residents on board not only helps tree maintenance but also creates a culture which generates volunteers. Having local volunteers become citizen scientists allows programs to cut staffing costs while also increasing the amount of work they can achieve. Federal, state, and municipal forestry programs should partner with high schools to reach students. High school students are often looking for volunteer hours to graduate or are trying to find internships to improve college applications. Showcasing potential career paths to young students also acts as a form of advertising for the forestry industry. Programs utilizing high school students provides useful jobs skills and also increase the environmental knowledge of their community. Youth can be enthusiastic messengers of knowledge to family, friends, and online social networks. Young people have created the world of social network sharing; therefore they are an important demographics reach out to. This expertise can show programs how information can be best conveyed to audiences.
Spreading awareness is also necessary in proving to municipal governments the need to invest in urban forestry programs. There is a lack of awareness of the multitude of benefits trees provide. Most people are aware of the basic benefits of oxygen creation and wildlife biodiversity trees create, but the majority of a forest’s work goes unnoticed. Programs need to add strong promotional divisions to their structures. The goal of these divisions is to compile the benefits of urban forestry and market these benefits clearly to engage and educate the urban audience. Awareness will bring high volunteer recruitment rates and a well-informed public. Awareness is key to increasing political pressure to financially supplement local urban tree programs. An interdisciplinary approach to policy, involving demonstrative technical assistance, deliberate funding, meaningful community outreach, and powerful awareness campaigns can grow urban forests capable of providing communities with aid for lifetimes.
Bibliography


Farm Bill “Public Law 101-624”. Nov 28 1990, p 104-STAT. 3534


Konijnendijk, Cecil C. *The Forest and the City* (New York: Springer, 2008)


Pinchot Institute for Conservation “Allocating Cooperative Forestry Funds to the States: Block Grants and Alternatives: A Report to the US Forest Service”, 8


Williams, Gerald W. (Summer 2000). "Introduction to Aboriginal Fire Use in North America" (PDF). Fire Management Today(USDA Forest Service) 60 (3): 8–12.