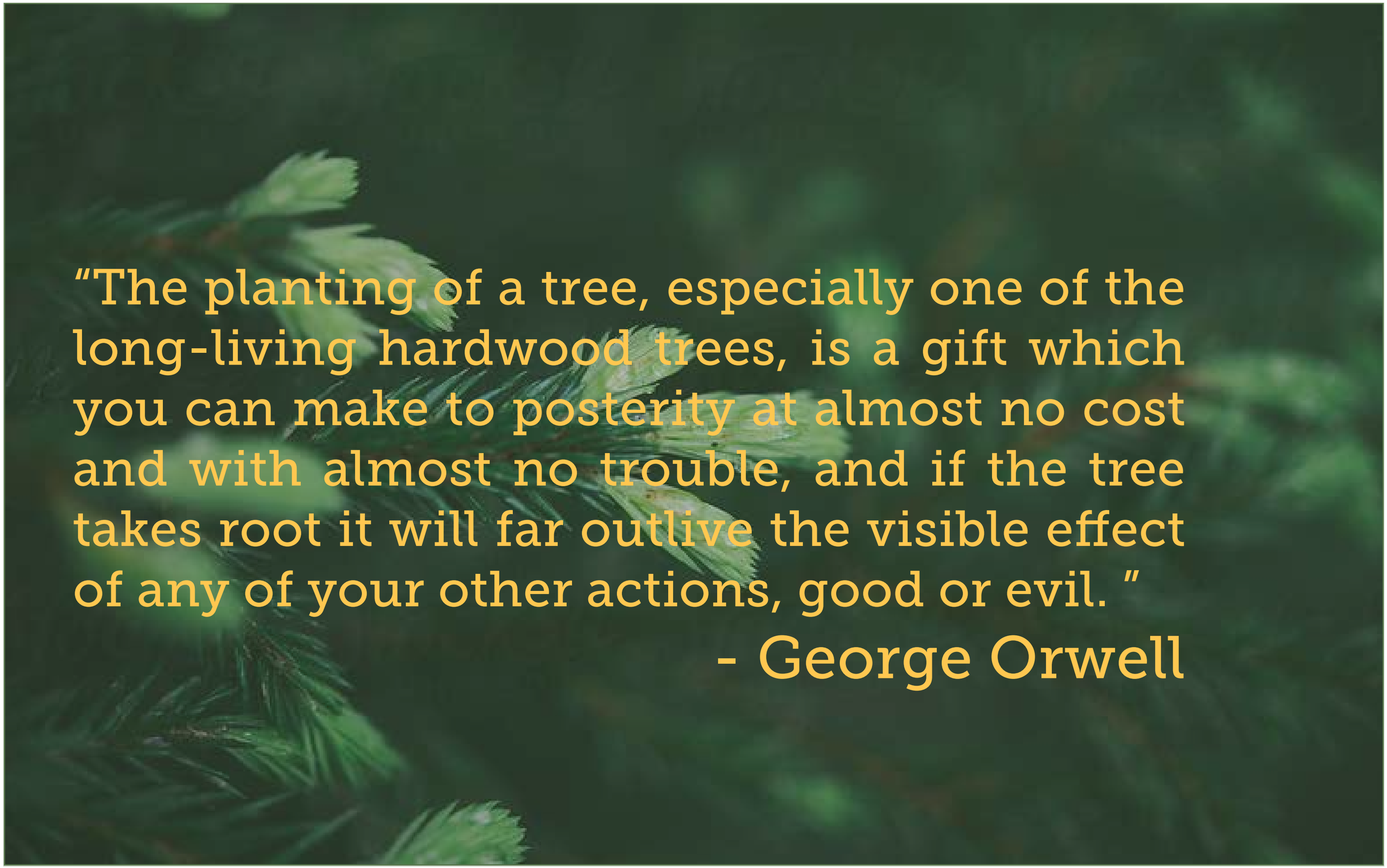
CITY OF BOULDER
URBAN FOREST STRATEGIC PLAN

Branching Out

Our Trees. Our Legacy.

Boulder Parks & Recreation


“The planting of a tree, especially one of the long-living hardwood trees, is a gift which you can make to posterity at almost no cost and with almost no trouble, and if the tree takes root it will far outlive the visible effect of any of your other actions, good or evil. ”
- George Orwell

City of Boulder
Urban Forest Strategic Plan

Our Trees. Our Legacy.

2018

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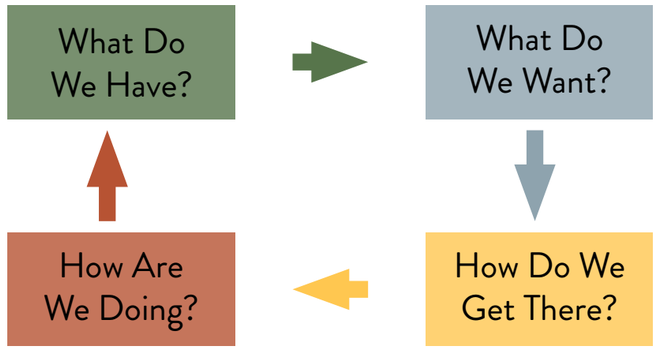
EXECUTIVE SUMMARY

Boulder is a thriving community which consistently ranks among the best places to live in America. Resources from Forbes to Gallup sing Boulder's praises; beautiful natural scenery, a robust economy, and the healthy lifestyle of Boulder residents. Boulder is home to many PhDs as well as numerous startups and corporate giants including Google, Microsoft, and Threadless. It's also a major government research hub, home to the National Center for Atmospheric Research and the National Institute of Standards and Technology.

Pristine natural surroundings offer easy access to mountain streams and lush forests. With more than 43,000 acres of open space, 151 miles of trails, 60 parks, and the Boulder Creek Path, which runs through the middle of town, this outdoor paradise promotes access to year-round recreation, including hiking, fishing, biking, and rock climbing. The community enjoys delicious local cuisine and farm-to-table eateries. Boulder's population has one of the lowest obesity rates (12.4%) of American cities (Riffkin, 2014), rated 10th in the 2016 overall Community Well-Being Rankings (Gallup-Healthways), and has been the nation's fittest community since 2009.

"The city will support, promote and, in some cases, regulate the protection of healthy existing trees and the long term health and vitality of the urban forest in the planning and design of public improvements and private development. The city will encourage overall species diversity, native and low water demand tree species where appropriate."

– Boulder Valley Comprehensive Plan



Boulder residents strongly support environmental protections. In 2013, Boulder became one of the first 32 cities chosen to participate in 100 Resilient Cities (100RC). Resilience is the ability to prepare for and respond effectively to stress. Resilient communities pledge to preserve the quality of life today and improve their legacy for future generations. By any metric, Boulder is a premier city with beautiful natural amenities, strong environmental values, and a quirky yet highly-skilled workforce. In sum, the people of Boulder are healthy, motivated, and educated. Urban trees support the active, outdoor lifestyle of residents.

An urban forest is the collection of trees that grow within a city or town. A resilient urban forest supports the resilience of the community. Stewardship of Boulder's urban forest is an important part of the resilience strategy. Boulder's urban forest currently provides an overall average canopy cover of 16% (2,773 acres) (Urban Tree Canopy Assessment, 2015) and includes approximately 650,000 trees on public and private land. Along with their aesthetic and socio-economic contribution, trees serve as a buffer to many environmental stressors by providing cooling shade, energy savings, cleaner air, wildlife habitat, and vital protection for creeks and streams by reducing stormwater runoff.

The Urban Forest Strategic Plan (UFSP) provides long-term management goals for increasing community safety and preserving and improving the health, value, and environmental benefits of this natural resource. The structure of the UFSP are based on the understanding of what we have, what we want, how we get there, and how we are doing. This structure, referred to as adaptive management, is commonly used for resource planning and management (Miller, R.W.) and provides a good conceptual framework for urban forest programming.

Map 1: Land Cover

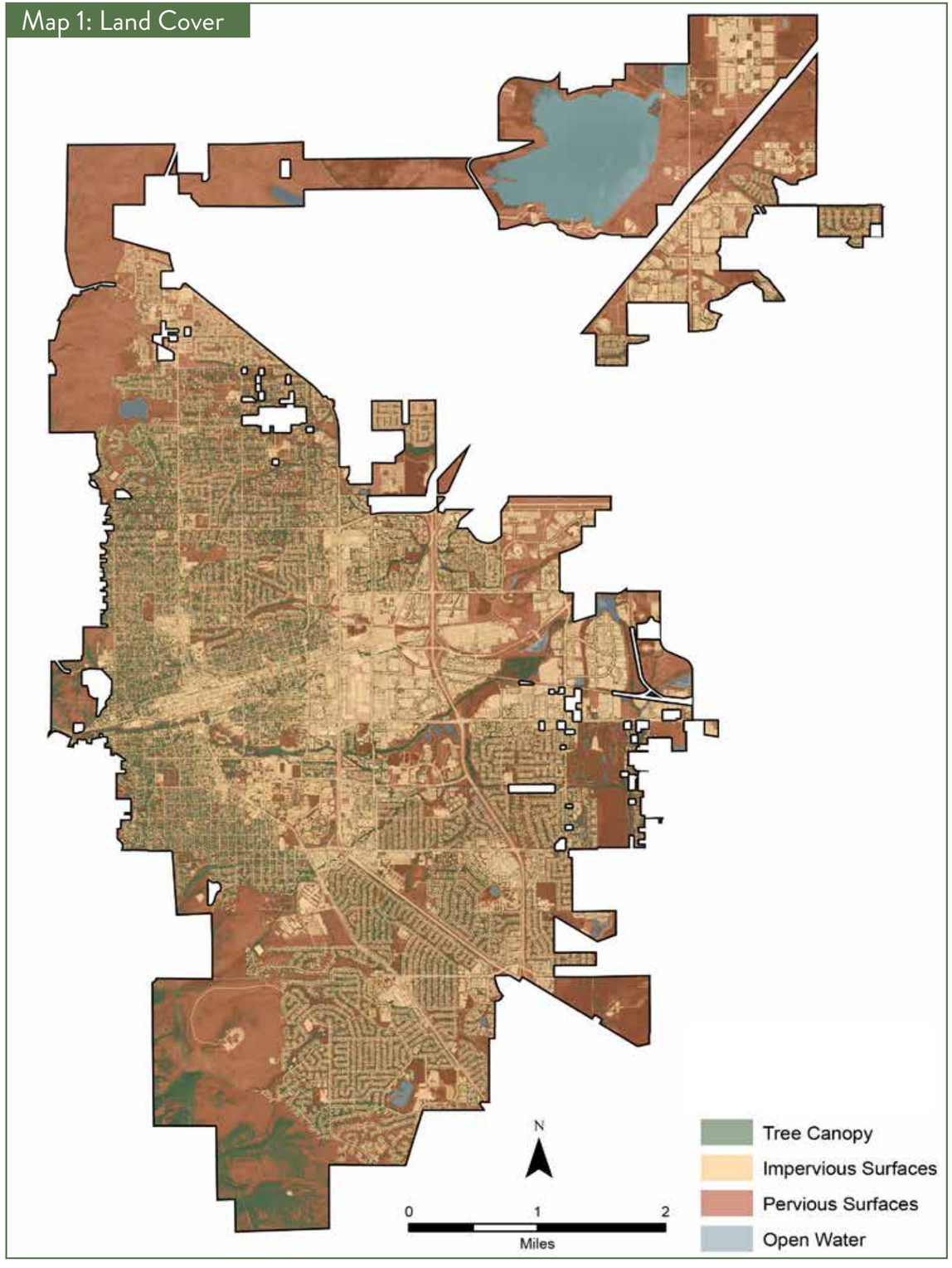


Chart 1: Land Cover

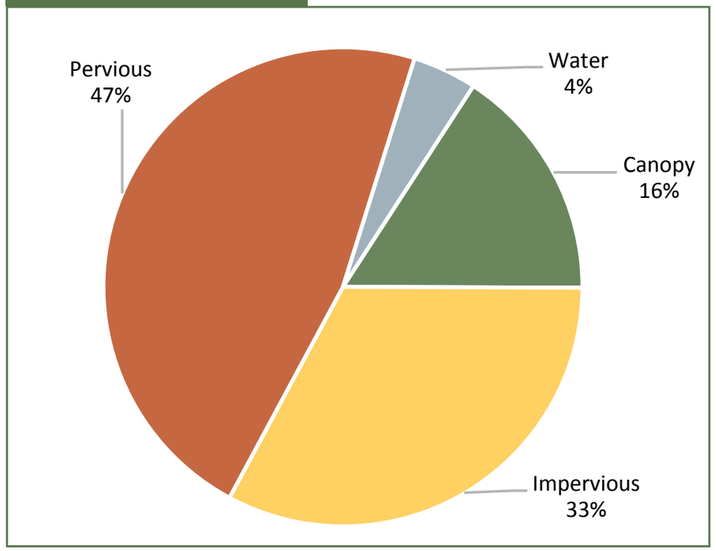


Table 1: Land Cover Classes

Land Cover Class	Acres	Percent
Canopy	2,773	16%
Impervious	5,724	33%
Pervious	8,198	47%
Water	755	4%
Total	17,450	100%

What Do We Have?

The development process for the UFSP involved a comprehensive review and assessment of:

- Existing urban forest resources, including composition, value and environmental benefits;
- Community vision, including those expressed by the Boulder Valley Comprehensive Plan, Boulder Resiliency Plan and Boulder Climate Action Plan;
- Guiding documents, including ordinance and tree protection policies, development and construction standards, and preservation requirements; and
- Forestry operations, including funding and current service levels for both in-house and contracted forestry staff.

The review process established that Boulder has built a strong foundation for an exceptional urban forestry program. The community has made an outstanding commitment to planting, preserving and promoting the care of trees and other natural resources. Much of Boulder's urban forest, including approximately 650,000 trees and 2,773 acres of canopy, is located on private property. The overall urban forest tree canopy is providing more than $876,000 in annual benefits to air quality, carbon sequestration, and avoided stormwater runoff (Urban Forest Resource Analysis, 2015).

In addition to 600,000 privately owned trees, nearly 50,800 community trees are located on streets, parks, and public Right-of-Way (ROW) (Urban Forest Resource Analysis, 2015). These city-managed trees are providing approximately 24 percent of all canopy cover (4 percent of overall Boulder acreage)and nearly $5.2 million each year in environmental services ($700,000) and increased property values ($4.5 million). To replace this public resource with trees of a similar size and species would cost nearly $110 million (Urban Forest Resource Assessment, 2015).

Boulder's Forestry Division exemplifies professionalism in their dedication to high-level standards in the management of the urban forest. The division employs seven full-time professionals who regularly participate in training and industry events to stay abreast of current advancements. They are dedicated to increasing the sustainability and resilience of the urban forest.

Forestry operations are robust and focused on best management practices (BMPs), emerging industry solutions, and the prudent application of available resources. In addition to standard services, like rotational pruning, tree removal and replacement, storm response, development review, and responding to customer service requests, Boulder's forestry operations include several exemplary programs that meet or exceed industry recommendations These programs include a Tree Safety Inspection Program (TSIP), Integrated Pest Management (IPM), wood debris management and an arborist licensing program.

Since 2013, the personnel, training, equipment and budget to support these activities have not kept pace, leading to longer pruning cycles, delayed responses and deferred maintenance.

The unique climate of the Front Range poses many challenges to the growth and survival of trees. At an elevation of 5,430 feet, there are few native tree species in this high desert region. Those trees that have been naturalized and cultivated in Boulder's urban forest face a constant barrage of threats, including temperature extremes, late spring freezes, snowstorms, flooding and drought.

Boulder was the first city in Colorado to identify the presence of emerald ash borer (EAB). This devastating pest is 100 percent deadly to untreated ash trees. EAB is responsible for the death of hundreds of millions of trees in more than 30 states. Ash trees account for more than 25 percent of Boulder's urban tree canopy and provide a significant contribution o environmental and socio-economic services to the community. It is estimated that there are more than 70,000 ash trees in Boulder, valued at approximately $18 million (including public, private and naturalized sites).

Since the identification of EAB in 2013, Boulder Forestry has been at the forefront of the state's EAB management program. Over the next two to five years, EAB will have a significant direct budgetary impact on Boulder and private residents. Although Boulder Forestry is providing pesticide treatments for many larger established ash trees, all untreated ash are expected to die from EAB over the next five years. As a result, Boulder is anticipating a 25 percent loss in existing tree canopy (with as much as 32 percent loss in some neighborhoods).

Table 2: Benchmark Values

Urban Forest Tree Population	
Number of All Trees	650,000
Average Trees Per Acre	37.2
Tree Canopy Cover (Public and Private Trees)	
Overall Canopy Cover	15.9%
Impervious Surfaces	32.8%
Maximum Urban Tree Canopy	40.7%
Annual Services (Public and Private Trees)	
Avoided Stormwater Runoff	$177,016
Carbon Dioxide Reduced	$676,508
Air Quality Improvement	$22,631
Total Annual Services	**$876,155**
Long-Term Benefits (Public and Private Trees)	
Stored Carbon	$17,056,868

Boulder's Public Tree Resource

Public Tree Resource Tree Population	
Number of Public Trees (2015)	50,800
Replacement Value of Public Trees	$109,955,170
Species Diversity (Public Trees)	
Number of Unique Species	235
Prevalance of Top Ten Species	50.7%
Species Exceeding Recommended 10%	1
Aesthetic Benefits (Public Trees)	
Property Value Increase	$4,493,582

What Do We Want?

In addition to forestry staff, there are multiple stakeholders, internal and external, who play a role in the planning, design, care and advocacy of the urban forest. The development of the UFSP included considerable outreach to engage and collaborate with forestry professionals, city leadership and the community.

Outreach included surveys, pop-up Tree Story Stations, a public open house, interviews with managing stakeholders, and technical working group meetings. Everyone who participated played a role and provided input for the development of the UFSP.

Overwhelmingly, stakeholders expressed the desire to preserve and grow tree canopy. While the reasons were varied, most participants recognize and appreciate the environmental services and contribution to the quality of life that the urban forest provides.

Many participants were aware of EAB and that trees are being removed as a result. Yet most respondents were not aware of the extent and gravity of the issue that is expected to result in the loss of 25 percent (~775 acres) of existing tree canopy.

Recognizing that the transformed canopy will have a considerable economic, social and environmental impact for decades to come, the UFSP suggests a goal of no-net-loss in overall tree canopy by 2037.

Realizing this goal will require a consolidated effort from the community, actions include:

- Engaging and preparing the community for canopy loss;
- Developing citywide and neighborhood planting plans;
- Setting minimum requirements for species diversity and large-stature trees;
- Planting 600 public trees each year;
- Facilitating the planting of 2,025 trees on private property each year; and
- Monitoring canopy cover for gains and losses.

While unquestionably devastating, managing the losses from EAB is a relatively short-term problem within the long-term, perpetual stewardship of Boulder's trees. An urban forest is a dynamic resource, constantly growing and responding to the environment and the care it receives.

The preservation and care of existing and new trees requires planning and sustainable resources to promote forest health, longevity, and greater resilience over time.

Recognizing this, stakeholders also identified areas of focus for the long-term stewardship of Boulder's urban forest, including:

- Maintenance and preservation of existing trees on both public and private property;
- Increased outreach and engagement with the Boulder community;
- Opportunities for volunteers and neighborhood leaders;
- Greater collaboration with local, regional, and state partners; and
- Sustainable funding.

Finally, the Boulder Valley Comprehensive Plan (BVCP) is the unifying document that communicates the community's vision for the future, identifies core values, and provides departmental master plans with clear plan components. The BVCP identifies specific values that are particularly relevant to the urban forest including great neighborhoods and open spaces, environmental stewardship and climate action, physical health, safety, and well-being, with sustainability as a unifying framework to meet environmental, economic and social goals. The principle of sustainability drives the overall framework of the BVCP and the UFSP.

How Do We Get There?

The UFSP identifies four goals for preserving the safety, health, value, services, and resiliency of Boulder's urban forest. The goals are supported through priorities and actions:

- **Plan,** including a priority to establish a no-netloss canopy goal of 16 percent by 2037. Additional priorities and actions include monitoring canopy cover for gains and losses, developing citywide and neighborhood planting plans, creating design strategies for maintaining irrigation to young trees during drought, and establishing minimum requirements for species diversity and large stature trees.
- **Manage**, including priorities and actions to consolidate all public tree care under Boulder Forestry, excluding trees managed by Boulder's Open Space and Mountain Parks (OSMP). Additional priorities and actions include, temporarily increasing annual planting budgets, facilitating and incentivizing tree planting on private property, continuing to implement the EAB response strategy, securing dedicated and sustainable funding to ensure that forestry operations meet community safety expectations, requiring protections for wildlife and critical habitat, and collaborating with regional partners for cost-sharing and bulk pricing.
- **Protect**, including an emphasis on trees as essential infrastructure. Additional priorities and actions include best management practices, industry standards for tree care, strengthen public tree protection, add protections for private trees, revise professional standards for tree care companies, water-efficient irrigation systems, and an enhanced role for forestry in development and construction projects.
- **Engage**, including priorities and actions to communicate measurable and objective information, facilitate understanding of urban forest challenges and canopy goals, expand the opportunities for community involvement in activities and plan-making processes, and to partner with the community on projects to broaden support and funding for the urban forest.

The UFSP provides long and short-term strategies for the next 20 years to ensure that Boulder's urban forest successfully aligns with the community's vision for a safe, sustainable, and resilient resource. Since Boulder can only directly affect public trees, (24 percent of all canopy cover), the plan recognizes that community engagement is integral to success.

How Are We Doing?

The long-term success of the UFSP will be measured through the realization of plan goals and demonstrated through the increased value and services provided by the urban forest. The plan identifies measurable actions, potential partners, relative cost and desirable time frames for priorities and actions. However, the UFSP is intended to be a dynamic tool that can and should be adjusted in response to available resources and emerging opportunities. One of the greatest measures of success for the UFSP will be its level of success in meeting community expectations for the care and preservation of Boulder's urban forest.

GOALS

Plan

PRIORITIES

- Develop and implement a 20-year Planting Plan for public trees to support the 16% urban tree canopy cover by 2037.
- Participate in an inter-departmental Urban Ecosystems Management Strategic planning process to integrate ecosystem protection and monitoring across urban, agricultural and wildland systems.
- Create an Urban Forest Emergency Response Plan for citywide coordination to ensure appropriate coverage and minimize risk to the public.

Manage

PRIORITIES

- Establish a dedicated, sustained funding source beyond the departmental budget for Boulder Forestry operations to increase the level of service to meet the community's high standards.
- Expand the Public Tree Planting program to support efforts toward the goal of 16% canopy by 2037.
- Shift management responsibility for all trees in public street ROW and around public buildings under Boulder Forestry to maximize advantages in expertise and scale.
- Increase investment in proactive, preventative maintenance by exploring options to increase the frequency of pruning events for public street trees.
- Refine the Integrated Pest Management (IPM) Program to improve tree health while minimizing cost and negative impacts to ecosystems and the public.
- Streamline the Tree Safety Inspection Program (TSIP) to manage risk and minimize City exposure to claims as well as reduce the financial and logistical costs on forestry operations.
- Continue implementation of the EAB response strategy to maintain public safety, ecosystem services, and forest function in the face of unprecedented canopy loss.
- Transition to a common software Asset Management System to allow efficient forestry business processes across city work groups and provide essential baseline data for strategic forest management.
- Continue to explore all wood utilization options to improve resiliency to increased cost or disappearance of any single waste stream.
- Explore the expansion of the Commercial Tree Program (CTP) beyond the immediate downtown area to maintain urban tree canopy, protect property and better manage public safety issues.
- Develop a staff succession plan within Forestry to encourage continual professional development and facilitate transitions in leadership to minimize disruption to operations.
- Deliver a State of the Urban Forest Report biennially for elected officials, key urban forest stakeholders, and the public.

Protect

PRIORITIES

- Strengthen Boulder Forestry's role in all city CIP projects to minimize damage to tree assets and canopy loss.
- Strengthen existing city requirements for trees on Public Property to increase tree protection, improve site preparation and strengthen tree species diversity requirements to maintain the urban tree canopy and increase forest resiliency.
- Strengthen existing and develop new city requirements for Private Property to increase tree protection, improve site preparation and strengthen tree species diversity requirements to maintain the urban tree canopy and increase forest resiliency.
- Revise licensing requirements for all tree care companies performing tree work in Boulder to improve public safety and tree health.

Engage

PRIORITIES

- Provide the community with balanced and objective information to assist them in understanding the problems, alternatives and options to achieve the Boulder urban tree canopy goal.
- Partner with the community on projects to broaden knowledge, support and funding for the Boulder urban tree canopy goal.
- Develop and expand opportunities for community involvement in the commitment to achieve the Urban Tree Canopy goal.
- Involve the public on the analysis, alternatives and recommendations for further urban forestry related planning processes and potential code changes.

Introduction

In 2016, Boulder contracted with the Davey Resource Group to develop an Urban Forest Strategic Plan (UFSP) to specifically address the unique challenges and opportunities Boulder's urban forest will face over the next 20 years.

Boulder's urban tree canopy cover was measured as 16 percent in 2013. Urban tree canopy cover is the layer of leaves, branches, and stems of all trees that cover the ground when viewed from above. A significant goal of this Plan is to maintain Boulder's 16 percent urban tree canopy cover. This goal was established because the urban forest faces many new threats, and will diminish quickly without proactive measures.

To achieve this 16% canopy goal, the time to act is now. Boulder is losing tree canopy at an alarming rate due to pests uch as EAB, severe weather events, and urban development.

There are approximately 650,000 trees in Boulder's urban forest. Of those trees, 50,800 are publicly owned street trees and park trees. These public trees are managed by Boulder, primarily through the Boulder Forestry Division. In Boulder, public trees have an appraised replacement value of over $110 million. That figure represents the cost to replace all the public trees with trees of comparable species, health and size. The urban forest also includes hundreds of thousands of trees on commercial, private and naturalized areas throughout Boulder.

Challenges and opportunities have emerged that require a proactive management approach and a long-term planning strategy to preserve the health, sustainability, and services of trees and canopy cover. The UFSP is important because it explains the many different policies, plans and actors that are involved in the management of the urban forest. The UFSP strengthens Boulder's ability to effectively provide the core forestry management services focused on safety, emergency response and sustainability. Cohesion between city staff and the public is vital because successful urban forest management demands a wide-reaching community effort.

Boulder also contracted with Two Forks Collective to coordinate community engagement during the planning process. Davey Resource Group is comprised of experts in arboriculture and urban forestry, and Two Forks Collective are experts in community engagement. Both firms are essential to the realization of Boulder's goal to preserve the existing citywide 16 percent urban tree canopy cover because Boulder can only directly affect public trees (24 percent of overall tree canopy cover). Therefore, community buy-in must occur to impact the remaining private trees (76 percent of overall tree canopy cover).

Who owns the 650,000 trees in Boulder's Urban Forest?

50,800 are public.

~600,000 are private.

ALL trees contribute to the urban tree canopy.

Services of Urban Trees & Canopy Cover

Trees in the urban forest work continuously to mitigate the effects of urbanization and development and protect and enhance lives within the community in many ways. Healthy trees are vigorous, producing more leaf surface and canopy cover area each year.

The amount and distribution of leaf surface area are the driving forces behind the urban forest's ability to produce services for the community (Clark et al, 1997). Services include:

- Health and Wellness;
- Reducing Atmospheric Carbon;
- Improving Air Quality;
- Capturing Stormwater Runoff and Improving Water Quality;
- Benefits to Wildlife;
- Aesthetic and Socio-economic Services; and
- Lessening Energy Demand.

Health and Wellness

Exposure to nature, including trees, has a healthy impact on humans, such as reduced symptoms of Attention Deficit Disorder (ADD), and faster recovery from surgery (Ulrich, 1984). Additional benefits include:

- Fortification of human health;
- Reduced illness, decreased reliance on medication, and quicker recovery from injury or illness;
- Higher test scores;
- Increased worker productivity; and
- Reduced symptoms of ADD.

The importance of green spaces in urban areas and the role they play in reducing crime and aggressive behavior has been recognized by sociologists. Research shows that the greener a building's surroundings are, the fewer total crimes. This is true for both property crimes and violent crimes. Landscape vegetation around buildings can mitigate irritability, inattentiveness, and decreased control over impulses, all of which are well-established psychological precursors to violence. Residents in public housing reported 25 percent fewer domestic crimes when landscapes and trees were planted near their homes (Kuo, 2001).

A study of individuals living in 28 identical high-rise apartment units found residents who live near green spaces had a stronger sense of community, better mental health, coped better with stress and hardship, were less aggressive and violent and managed problems more effectively than those living away from green space (Kuo, 2001).

Besides offering children a place to play, natural settings contribute to child development in at least four critical areas. Children who spend time in green settings have improved:

- Creativity;
- Imagination and cognitive function; and
- Intellect.

Children with ADD experienced reduced symptoms when exposed to green environments and spending time in nature (Faber, 2009).

A Potential Natural Treatment for Attention-Deficit/Hyperactivity Disorder: Evidence From a National Study (Frances E. Kuo, and Andrea Faber Taylor)

Objectives. We examined the impact of relatively "green" or natural settings on attention-deficit/hyperactivity disorder (ADHD) symptoms across diverse subpopulations of children.

Methods. Parents nationwide rated the aftereffects of 49 common after-school and weekend activities on children's symptoms. Aftereffects were compared for activities conducted in green outdoor settings versus those conducted in both built outdoor and indoor settings.

Results. In this national, non-probability sample, green outdoor activities reduced symptoms significantly more than did activities conducted in other settings, even when activities were matched across settings. Findings were consistent across age, gender and income groups; community types; geographic regions; and diagnoses.

Conclusions. Green outdoor settings appear to reduce ADHD symptoms in children across a wide range of individual, residential, and case characteristics.

Reducing Atmospheric Carbon

Governments are paying particular attention to climate change and the effects of greenhouse gas (GHG) emissions. As energy from the sun (sunlight) strikes the earth's surface, it is reflected back into space as infrared radiation (heat). Greenhouse gases absorb some of this infrared radiation and trap this heat in the atmosphere, increasing the temperature of the earth's surface.

Many chemical compounds in the earth's atmosphere act as GHGs, including methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), water vapor, and human-made gases and aerosols. As GHGs increase, the amount of energy radiated back into space is reduced, and more heat is trapped in the atmosphere. An increase in the average temperature of the earth and results in changes in weather, sea levels, and land-use patterns commonly referred to as "climate change." In the last 150 years, since large-scale industrialization began, the levels of some GHGs, including CO_2, have increased by 25 percent (U.S. Energy Information Administration, 2014).

The USDA Forest Service Urban Ecosystems and Social Dynamics Program recently led the development of an Urban Forest Project Reporting Protocol. Incorporating methods of the Kyoto Protocol and Voluntary Carbon Standard, the protocol establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides urban forest managers in developing tree planting and stewardship projects that could be registered for GHG reduction credits (offsets). The protocol can be applied to urban tree planting projects within municipalities, campuses, and utility service areas anywhere in the United States.

Trees and forests reduce atmospheric carbon dioxide (CO_2) in two ways:

- Directly, through growth and carbon sequestration; and
- Indirectly, by lowering the demand for energy.

Trees and forests directly reduce CO_2 in the atmosphere through growth and sequestration of CO_2 in woody and foliar biomass. Indirectly, trees and forests reduce CO_2 by lowering the demand for energy and reducing the CO_2 emissions from the consumption of natural gas and the generation of electric power. In fact, the shade from a single tree can save the same amount of energy as what ten room-size air conditioners need to run for 20 hours a day (Forest Service Pamphlet no. FS-363, as cited in Sherer, 2006).

- One mature tree can absorb as much as 48 pounds CO_2 annually and provides enough O_2 to support two human beings (McAliney, 1993); and
- Projections from computer simulations indicate that 100 million mature trees in U.S. cities (three trees for every other single-family home) could reduce annual energy use by 30 billion kWh, reducing nine million tons per year in carbon dioxide emissions from power plants (Dwyer et al., 1992).

Carbon Storage

Trees are powerful living infrastructure in their ability to store large amounts of carbon in their wood, and continue to add carbon as they grow. Although forests do release some carbon dioxide from natural processes such as respiration and decay, a healthy forest typically stores carbon at a greater rate than it releases carbon.

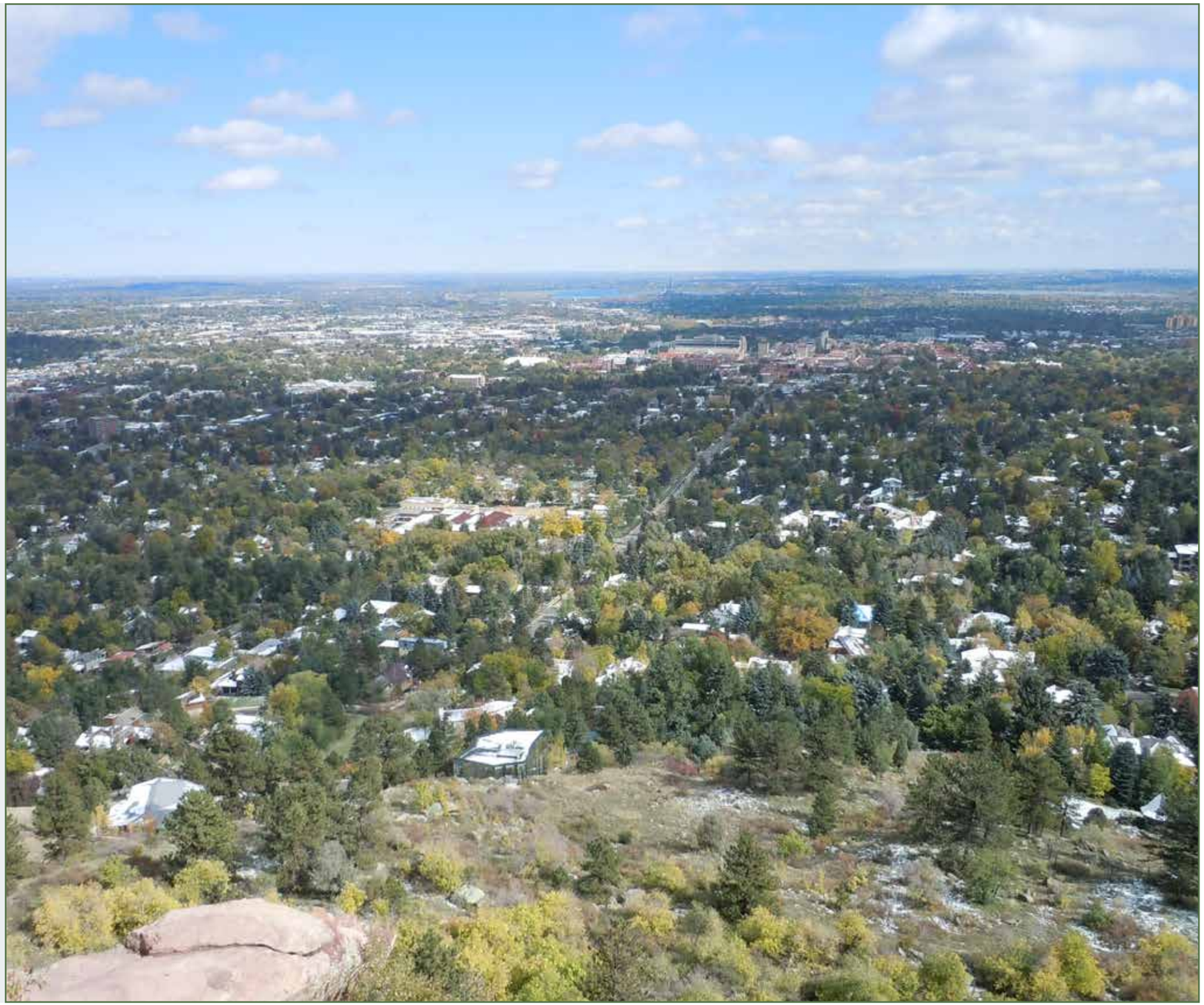
Improving Air Quality

Trees improve air quality in five fundamental ways:

- Lessening particulate matter (e.g., dust and smoke);
- Absorbing gaseous pollutants;
- Providing shade and transpiring;
- Reducing power plant emissions by decreasing energy demand among buildings; and
- Increasing oxygen levels through photosynthesis.

Trees protect and improve air quality by intercepting particulate matter (PM_{10}), including dust, pollen, and smoke. The particulates are filtered and held in the tree canopy until precipitation rinses the particulates harmlessly to the ground. Trees absorb harmful gaseous pollutants like ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). Shade and transpiration reduce the formation of O_3, which is created at higher temperatures. Scientists are now finding that some trees may absorb more volatile organic compounds (VOCs) than previously thought (Karl, T. 2010; Science Now, 2010). VOCs are carbon-based particles emitted from automobile exhaust, lawnmowers and other human activities. The Hidden Values of Landscaping demonstrates that the Urban Tree Canopy (UTC) provides air quality services valued at more than $500,000 in Denver and $1.7 million to the entire Denver metro area (Johnson et al., 2017).

The Urban Tree Canopy Assessment conducted for Boulder revealed that the Urban Tree Canopy annually removes 278,780 pounds of particulate matter and harmful gaseous pollutants (valued at $22,631).

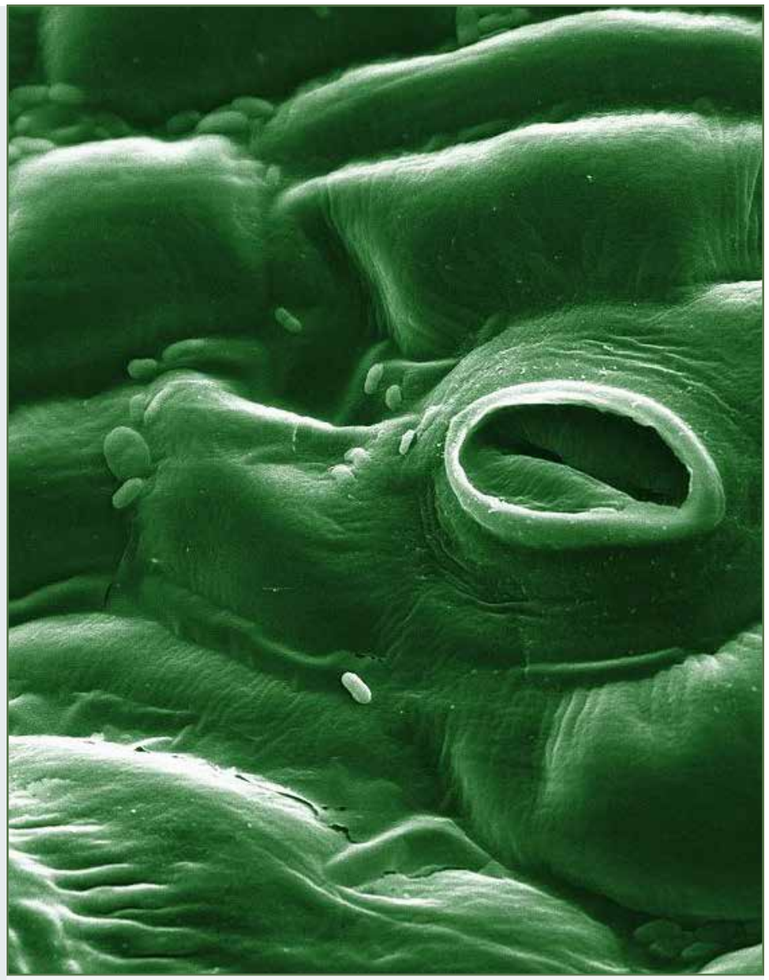


Removal of Air Pollutants

Cities and some natural processes produce air pollution including smoke, dust, carbon monoxide and smog. Poor air quality harms human and natural health. Leaves are the primary tool trees use to remove air pollutants.

Trees remove gaseous air pollution primarily by uptake via leaf stomata, though some gases are removed by the plant surface.

Once inside the leaf, gases diffuse into inter cellular spaces and may be absorbed to form acids or react with inner-leaf surfaces. Trees also remove pollution by intercepting airborne particles.



During normal opening of stomate pores (above), smog pollutants such as chlorine, sulfur dioxide and fluorides may enter. The tree uses some of these materials as food, and releases others into the air or soil.

In this way, trees receive vital nutrition and also help purify the air.

Capturing Stormwater Runoff

Stormwater is water that occurs from precipitation events and snow melt. Stormwater can soak into vegetation and soil (infiltration), collect on the surface and evaporate, or runoff and end up in nearby rivers, streams, or other bodies of water.

Trees and forests augment traditional stormwater management infrastructure and reduce the risk of flooding. This protects water quality in creeks, rivers, ponds, and lakes by reducing the impact from nonpoint source pollutants (Matteo et. al., 2006). Specifically:

- Interception of rainfall in tree canopy reduces the risk of flooding by slowing rainfall and providing a greater opportunity for infiltration;
- Tree root zones, which often extend well beyond canopy, promote infiltration of stormwater and increase the water holding capacity of the soil; and
- Slowing rainfall and increasing infiltration preserves soil quality by reducing erosion, especially on slopes and bare soils.

Trees intercept rainfall in their canopy, which acts as a mini-reservoir (Xiao et al, 1998). During storm events, this interception reduces and slows runoff. In addition to catching stormwater, canopy interception lessens the impact of raindrops on barren soils. Root growth and decomposition increase the water holding capacity and infiltration rate of soils allowing for greater absorption of rain and snowmelt (McPherson et al, 2002). Each of these processes greatly reduces the flow and volume of stormwater runoff, avoiding erosion and preventing sediments and pollutants from entering the water.

Trees in urban areas protect water quality by reducing the amount of runoff from the more frequent but less extreme storm events that are responsible for most annual pollutant runoff. Infiltrating and treating stormwater runoff on site can reduce runoff and pollutant loads by 20 to 60 percent (Johnson et al., 2017). The extensive fibrous root systems of trees also hold soil in place, reducing further impacts on water quality due to erosion.

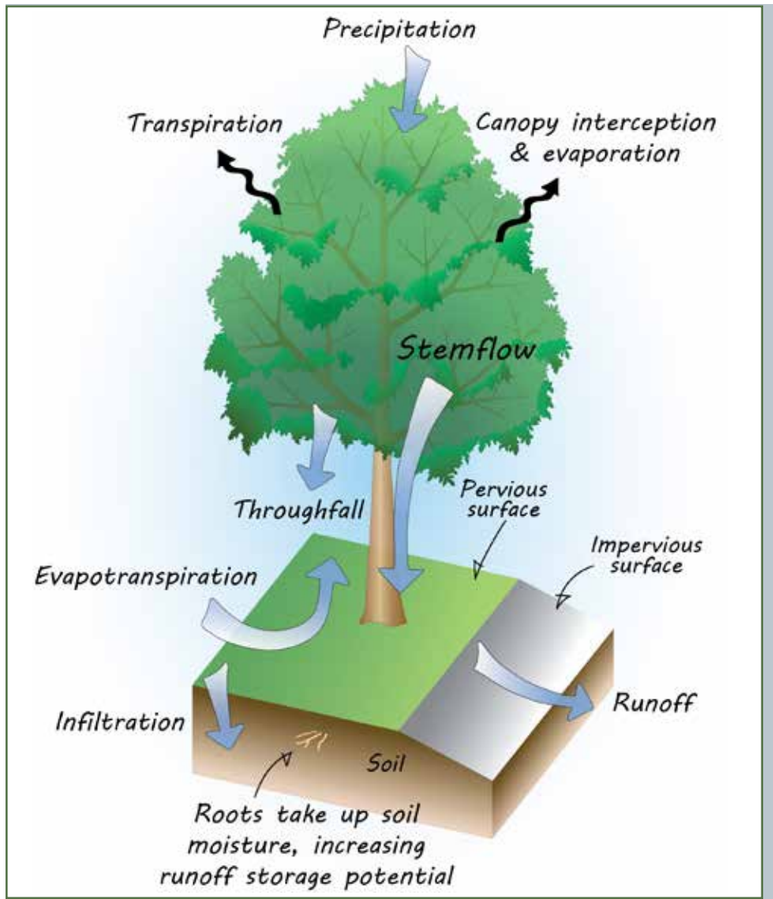
Planting trees in and adjacent to ROW provides a unique opportunity to increase the effectiveness of grey and green stormwater systems. Existing stormwater management systems are not always adequate to accommodate runoff. When a system is overtaxed, peak flows can blow manhole covers from the ground and back up stormwater. Where existing systems are challenged by common stormwater events, planting additional trees is a cost-effective way to improve functional capacity. To reduce pressure on existing systems and increase capacity, cities must consider every available option, especially using trees, to help manage stormwater.

Improving Water Quality

Urban stormwater runoff is a major source of pollution for surface waters and riparian areas, threatening aquatic and other wildlife as well as human populations. Requirements for stormwater management are becoming more stringent and costly. Reducing runoff and incorporating urban trees in stormwater management planning has the added benefit of reducing the cost of stormwater management, including the expense of constructing new facilities necessary to detain and control stormwater as well as the cost of treatment to remove sediment and other pollutants.

While Colorado has numerous river systems, more water leaves the state than remains within it. More than 60 percent of naturally flowing water leaves the state and is consumed by downstream users (Johnson et al. 2017). Of the approximately 40 percent that remains, local landscapes only use approximately 3 percent of all water consumed in Colorado (Johnson et al. 2017).

Extensive research conducted worldwide provides evidence that stream degradation occurs with as little as 10 percent impervious cover. During storms, accumulated pollutants are quickly washed off and rapidly delivered to aquatic systems as stormwater runoff. In a typical small-scale storm event (0.5 inch), highly concentrated and polluted stormwater would, without interference, flow directly into Boulder‘s waterways (Johnson et al., 2017). These small storms are responsible for most of the pollutant washout, also known as the first flush effect. Urban stormwater runoff is the second most common source of water pollution for lakes and estuaries and the third most common source for rivers nationwide.



Stormwater Management

Trees and forests are a natural, cost-efficient, and highly effective part of a stormwater management program. Many communities are turning to trees to help solve their stormwater issues in a more holistic manner. Engineered and natural stormwater systems that incorporate and take advantage of the natural benefits provided by trees and forests are proving to be a cost-effective and sustainable treatment method.

Benefits to Wildlife

Trees provide important habitats for numerous birds, insects (including honeybees) and other animal species. Their greatest contributions include:

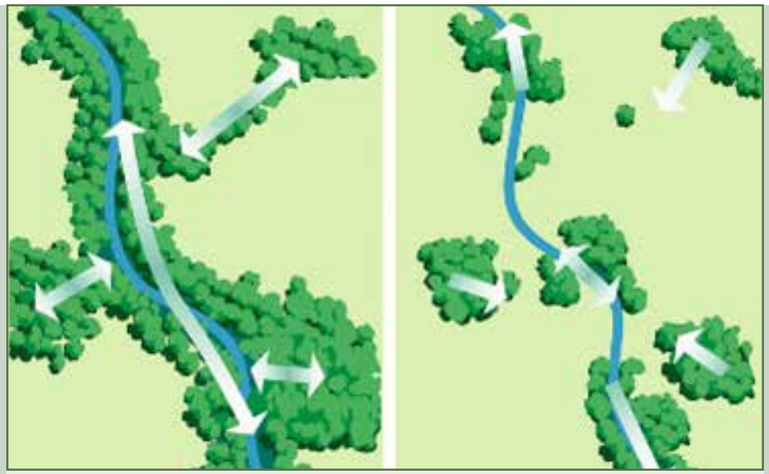
- Preservation and optimization of wildlife habitat; and
- Increase in movement corridors for wildlife.

Furthermore, trees and forest lands provide critical habitat (for foraging, nesting, spawning, etc.) for mammals, birds, fish and other aquatic species.

Trees can offer pollinators a valuable source of flowering plants. By including an array of flowering trees that provide pollen and nectar in the urban forest, honeybees are provided with additional food sources.

Fragmentation not only causes loss of the amount of habitat, but by creating small, isolated patches it also changes the properties of the remaining habitat. At some point when the larger forest is highly fragmented, there are no longer adequate corridors for native forest plants and wildlife. In fact, habitat fragmentation can reduce biodiversity by 75 percent and impairs key ecosystem functions by decreasing biomass and altering nutrient cycles (Haddad et al., 2015).

Some urban adaptable species benefit from the mosaic of green spaces even when “forest” wildlife species are negatively impacted by fragmentation, such as squirrels.



Forest Fragmentation

Wildlife corridors (left) link habitats while fragmented forests (right) lead to a decline habitat quality.

To enhance wildlife habitat, numerous communities have developed programs to preserve valuable existing natural areas and to restore the habitat on degraded lands. Restoration of urban riparian corridors and their linkages to surrounding natural areas have facilitated the movement of wildlife and dispersal of flora (Dwyer et al., 1992). Usually habitat creation and enhancement increase biodiversity and complement many other beneficial functions of the urban forest. These findings indicate an urgent need for conservation and restoration measures to improve landscape connectivity, which will reduce extinction rates and help maintain ecosystem services (Haddad et al., 2015).

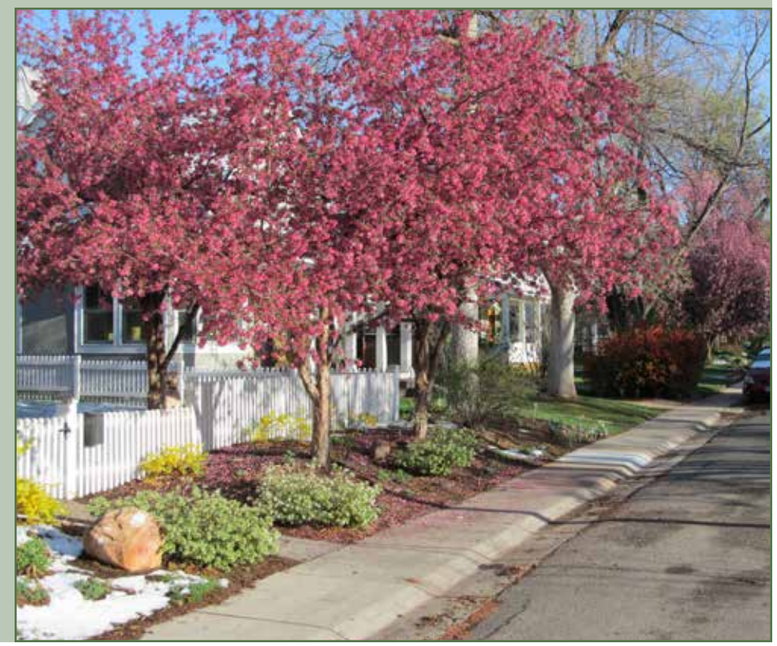
Aesthetic and Socio-economic Services

While perhaps the most difficult to quantify, aesthetic and socio-economic services from trees may be among their greatest contributions, including:

- Beautification, comfort and aesthetics;
- Increase in shade and privacy;
- Opportunities for recreation;
- Increased community walkability;
- Reduction in violence;
- Creation of a sense of place and history; and
- Increased property values.

Some of these services are captured as a percentage of property values, through higher sales prices where individual trees and forests are located. While some of the services of forests are intangible and/or difficult to quantify (e.g., the impacts on physical and psychological health, crime, and violence), studies provide empirical evidence that these services do exist (Kaplan, 1989; Ulrich, 1986). There is limited knowledge about the physical processes at work, and their interactions make quantification imprecise. In addition, trees and forests have positive economic services for retailers. There is documented evidence that trees promote better business by stimulating more frequent and extended shopping and a willingness to pay more for goods and parking (Wolf, 2007).

Trees also increase public and private property values. Every dollar invested in a residential landscape yields a $1.35 (135%) return for property values (Johnson et al. 2017). A high to excellent quality landscape is estimated to increase property values as much as 10 percent. Research has shown a 7 percent higher rental rate for commercial offices having high quality landscaping. Especially well-kept large street trees add a 3-15 percent value to a home and continue to appreciate in value over time (Johnson et al. 2017).



Lessening Energy Demand

Urban trees and forests modify climate and conserve energy in three principal ways:

- Producing shade for dwellings and hardscape reduces the energy needed to cool the building with air conditioning (Akbari et al., 1997);
- Tree canopies engage in evapotranspiration, which leads to the release of water vapor from tree canopies and cools the air (Lyle, 1996); and
- Trees in dense arrangements may reduce mean wind speed and solar radiation below the top of the tree canopy by up to ~90 percent compared to open areas (Heisler and DeWalle 1988).

An urban heat island (UHI) is an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities.

Trees reduce energy use in summer by cooling the surrounding areas and shading-built environments. Shade from trees reduces the amount of radiant energy absorbed and stored by hardscapes and other impervious surfaces, thereby reducing the heat island effect, a term that describes the increase in urban temperatures in relation to surrounding locations. Transpiration releases water vapor from tree canopies, which cools the surrounding area. Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2–9 degrees Fahrenheit (1–5 degrees Celsius) (Huang et al., 1990). The energy-saving potential of trees and other landscape vegetation can mitigate urban heat islands directly by shading heat-absorbing surfaces, and indirectly through evapotranspirational cooling (McPherson, 1994). Studies on the heat island effect show that temperature differences of more than 9 degrees Fahrenheit (5 degrees Celsius) have been observed between city centers without adequate canopy cover and more vegetated suburban areas (Akbari et al, 1997).

Trees also reduce energy use in winter by mitigating heat loss. Trees reduce wind speeds by up to 50 percent and influence the movement of warm air and pollutants along streets and out of urban canyons. By reducing air movement into buildings and against conductive surfaces (e.g., glass and metal siding), trees reduce conductive heat loss from buildings, translating into potential annual heating savings of 25 percent (Heisler, 1986).

Three trees properly placed around the home can save $100-$250 annually in energy costs. Shade from trees significantly mitigates the urban heat island effect – tree canopies provide surface temperature reductions on wall and roof surfaces of buildings ranging from 20-45 degrees and temperatures inside parked cars can be reduced by 45 degrees. Reducing energy use has the added bonus of reducing carbon dioxide (CO_2) emissions

Trees reduce energy use in buildings by creating shade and evapotranspiring in the hot summer months.

Trees also reduce energy use in buildings by blocking cold winter winds.

Figure 1: Cooling Effect of Tree Shade (Balogun et al., 2014)

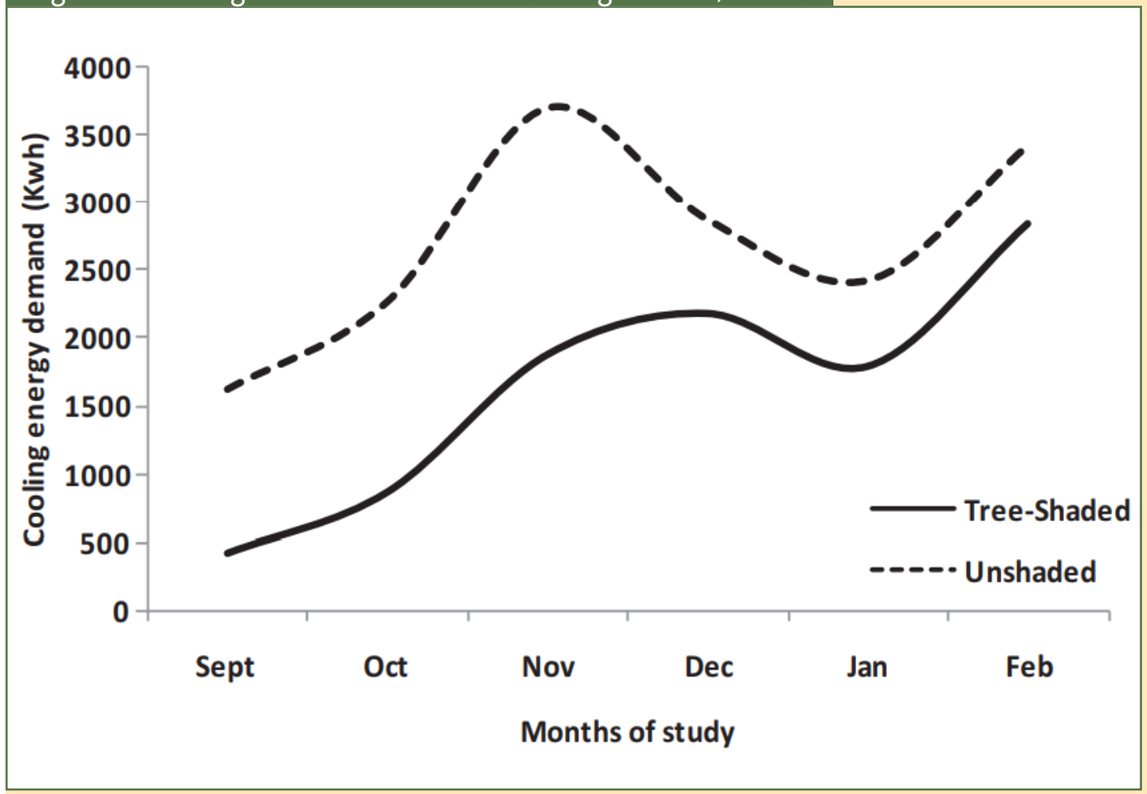
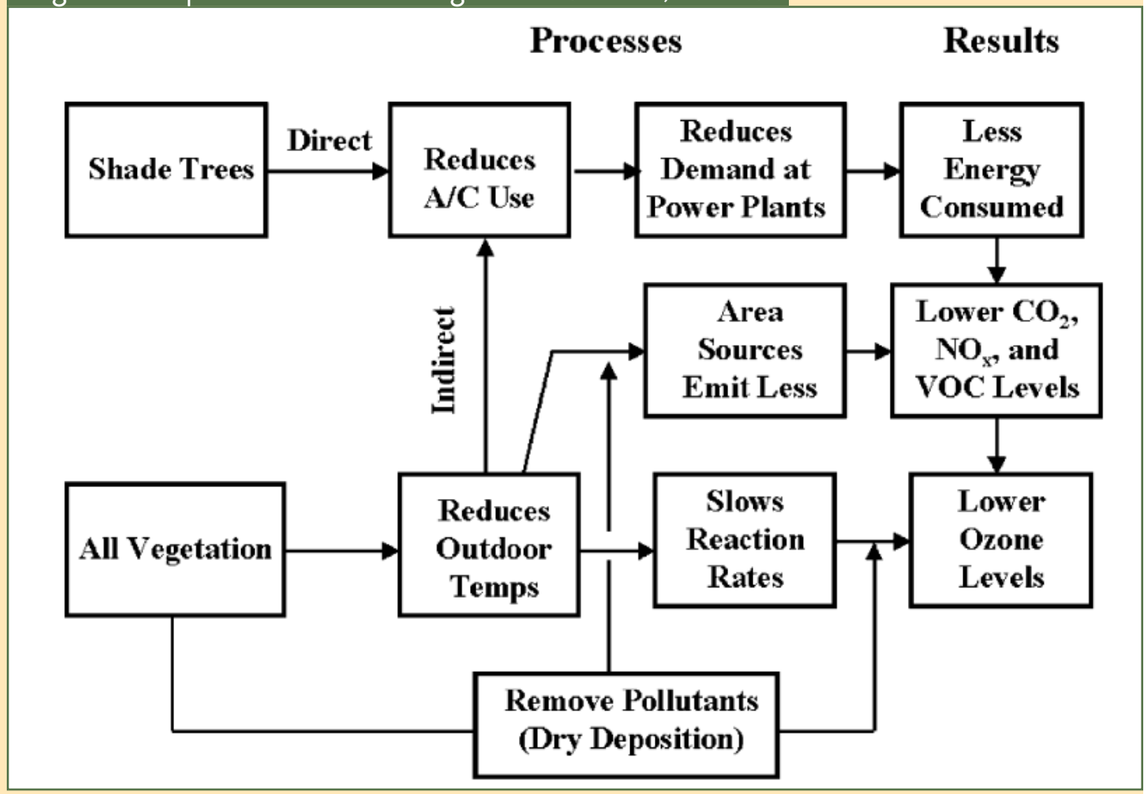


Figure 2: Impact of Trees and Vegetation (Akbari, 2002)



Block Hot Summer Sun

Trees lower energy demand in summer by providing shade to the built environment (Figure 1). Because there are many different tree species, trees with appropriate sizes, densities, and shapes are available for almost any shading situation. Trees also provide shade for windows that would otherwise receive direct sunlight. This lower energy demand means that less energy is consumed from the power plant and less pollution is created (Figure 2).

Block Cold Winter Winds

Winds make winter cold significantly worse. Trees can block the chilling effects of winter winds to keep a house warmer in winter. The most effective way is to plant a windbreak, a band of evergreen and deciduous trees and shrubs located perpendicular to the prevailing winds. The best windbreaks block the wind close to the ground as well as higher up.

Evapotranspiration

Trees cool the air through a process called evapotranspiration.

Evapotranspiration is the combination of two processes which occur simultaneously: evaporation and transpiration. Both of these processes release moisture into the air and lower surrounding temperatures. This means that buildings near trees experience cooler temperatures and require less energy for air conditioning.

What Do We Have?

Community

Boulder is located 25 miles northwest of Denver, Colorado, in Boulder Valley where the Rocky Mountains meet the Great Plains. To the west, iconic sandstone slabs of the Flatirons provide a scenic backdrop and multiple recreational opportunities.

The environment plays a significant role in urban forestry. The elevation, precipitation rates, temperature extremes and soil condition all affect what tree species grow, how they grow and levels of stress. At an altitude of 5,430 feet above sea level, Boulder is considered the high desert.

The climate is dry to semi-arid, typical for much of the Front Range. The high elevation fosters a mild climate with very little humidity in the summer and winter months. The warmest month is July with an average daytime temperature of 87 degrees Fahrenheit. January is the coldest month in Boulder, with an average daytime high of 45 degrees Fahrenheit. Boulder receives an annual average rainfall of 21 inches and snowfall of 89 inches. Precipitation patterns are influenced by the Flatirons' rain shadow effect, which dries the air as it passes over the Front Range.

Historically, Boulder had very few trees. Originally the area was a largely treeless plain. In 1871, a tree-planting program as initiated which established the beginning of Boulder's urban forest (University of Colorado, 2018).

As of 2017, Boulder had approximately 46,094 housing units, 108,707 residents, and 100,148 jobs. About 30,000 students attend the University of Colorado (CU). Over the next 25 years, the area is projected to add about 6,500 housing units, 19,000 residents and 19,000 jobs. CU student enrollment could increase by a range of 5,000 to 15,000 additional students by 2030. Boulder's population is expected to continue the trend of growth (Table 3).

Outdoor recreation activities abound in and near Boulder, including biking, hiking, rock climbing, and snow sports. Boulder manages over 45,000 acres of land, including 151 miles of trails within the Open Space and Mountain Parks Department, and more than 60 city parks, including sports fields, playgrounds, neighborhood parks and community gardens.

The people of Boulder value nature and personal health. Outdoor camps and organized recreation activities are popular with community members. Since 2009 Boulder has been the nation's fittest community, with only 12.4 percent of residents reported to be obese (Gallup-Healthways Wellbeing Index, 2016).

Boulder has earned a reputation for working proactively to reduce the city's environmental impacts with established city programs to:

- Combat climate change;
- Reduce energy waste;
- Promote the health of urban farming and natural ecosystems;
- Support the production of local foods;
- Reduce, recycle and compost waste, with an aim of zero waste;
- Conserve water and maintain water quality; and
- Reduce the use of pesticides on public property.

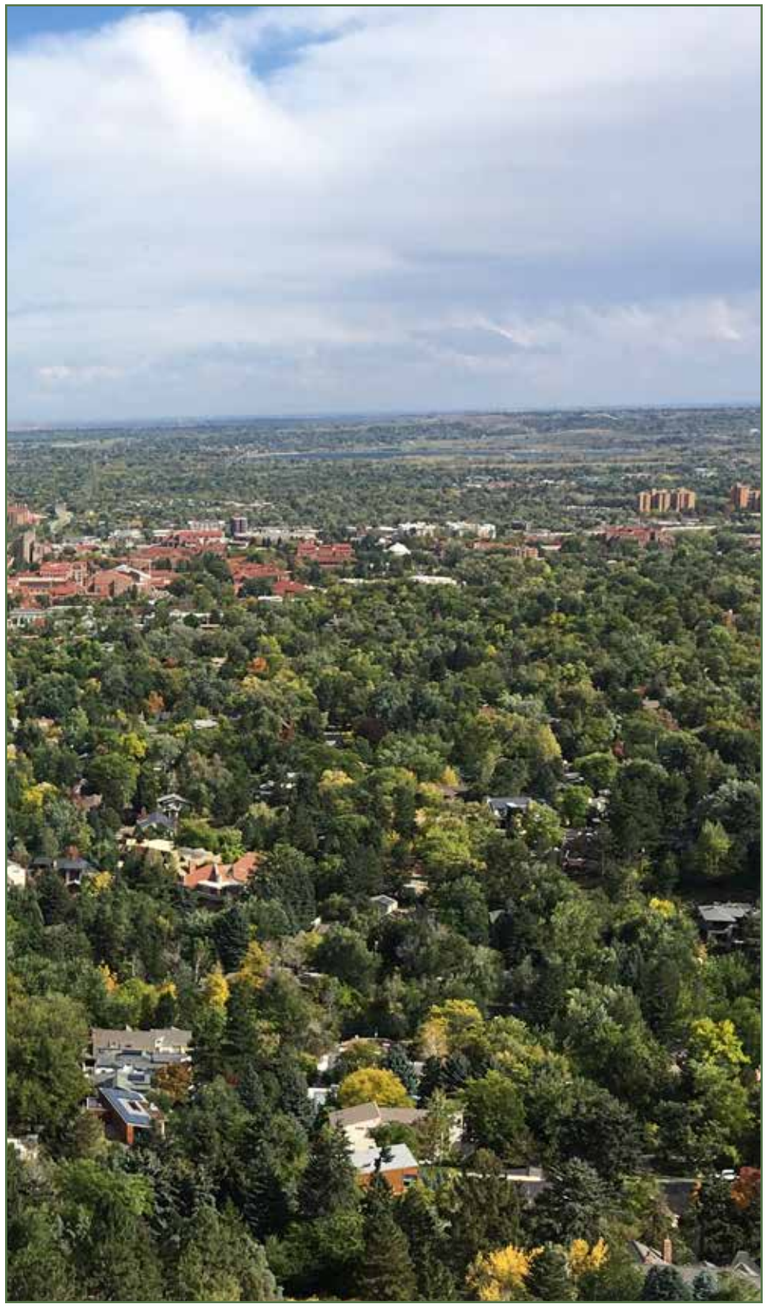
The community's outdoor lifestyle, environmental stewardship and high quality of life make Boulder an attractive location for established and emerging businesses.

The city has a culture of innovation and entrepreneurial support that helps businesses thrive, and the University of Colorado Boulder (CU) hosts more than a dozen federal research labs and growing companies in a variety

of industries. Boulder has an identity as a welcoming and inclusive community with a culture of creativity and innovation. The city actively supports businesses through the Economic Vitality Program, which provides information and assistance to Boulder companies. Boulder is frequently recognized for its quality of life as well as its business climate. Recent accolades include no. 1 Best Community for Physical Well-Being, no. 1 Most Active City in the U.S., and no. 4 Best City to Launch a Startup in 2016 (Bouldercolorado.gov). Through these traits and actions, it is clear that Boulder is a community dedicated to resilience.

Table 3: Boulder's Population

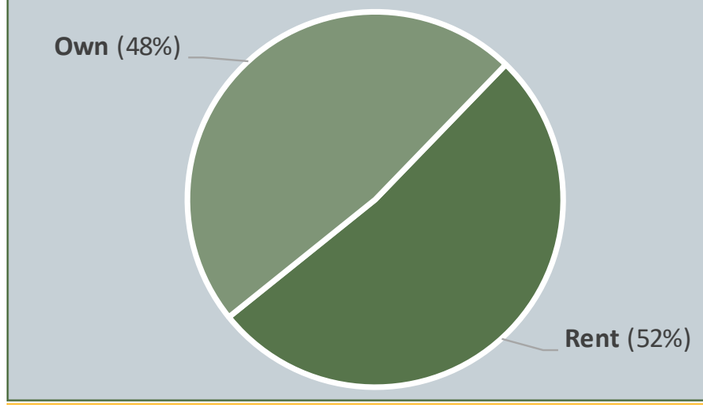
Year	Population
1870	343
1880	3,069
1890	3,330
1900	6,150
1910	9,539
1920	11,006
1930	11,223
1940	12,958
1950	19,999
1960	37,718
1970	66,870
1980	76,685
1990	86,098
2000	94,213
2010	97,385
2014	105,112



Where Do People in Boulder Live?

Per the 2017 community profile, 52 percent of Boulder residents live in rental units while 48 percent live in housing they own. This has significant implications for the urban forest regarding notifications. If a street tree located adjacent to a rented property will receive care from the city, who does the city contact? The renter or the property owner? Both? Who is responsible for private tree care and maintenance? To meet this challenge, the City of Boulder tracks this information in GIS.

Chart 2: Rent vs Own



I have a beautiful cottonwood tree in my backyard that is very old. The tree Was the original homestead tree. My family has done all we can to keep the tree healthy and alive. I feel very spiritually attached to this tree.

~Submission to Boulder Tree Stories

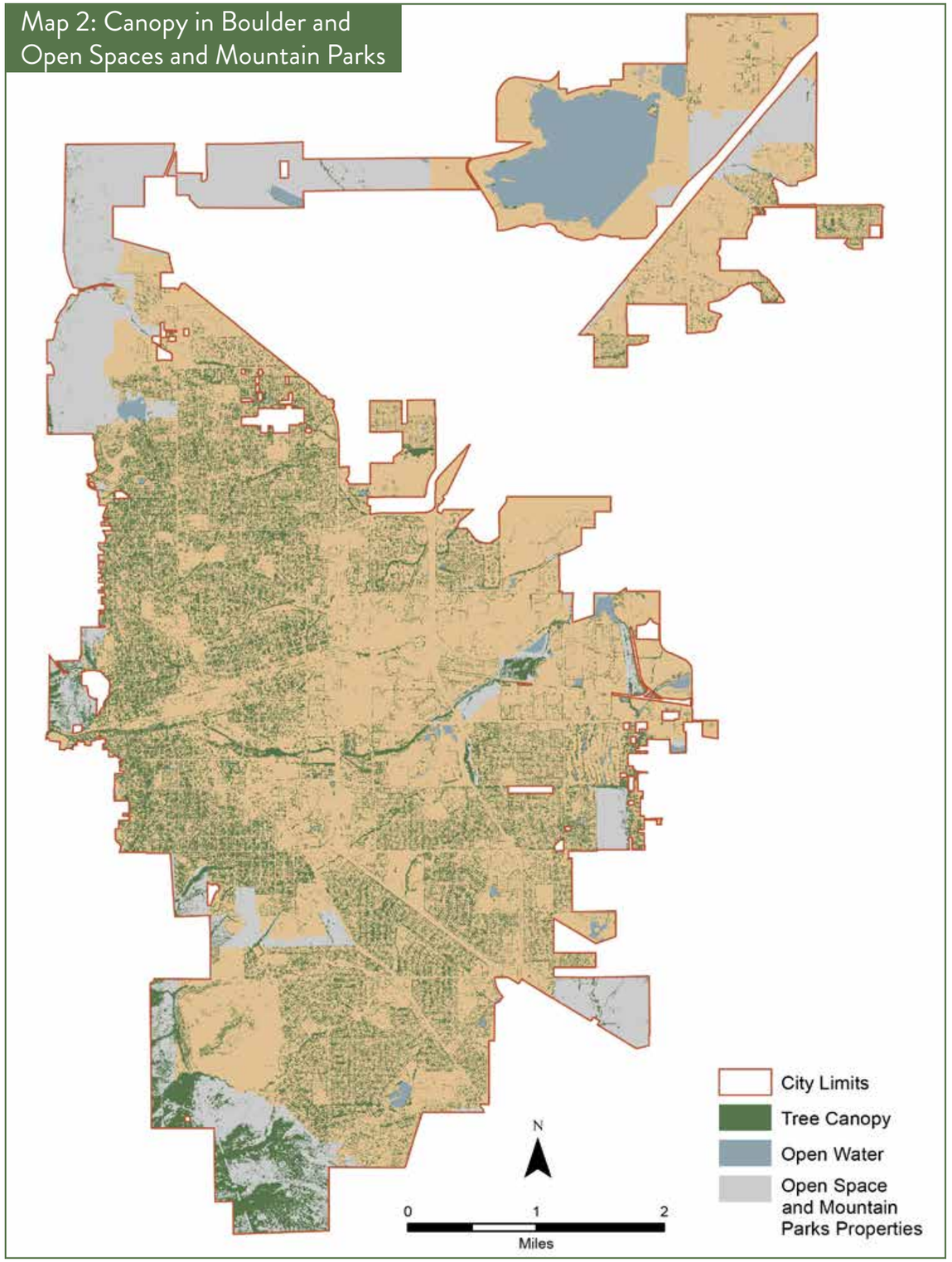
What is the Urban Forest?

Urban forests come in a variety of different shapes, types and sizes. Urban forests include trees found in urban parks, street trees, landscaped plazas, gardens, creek and ditch corridors, greenways, wetlands, private property and commercial and industrial campuses. Urban forests, through the many ecosystem services they provide, form a network of green infrastructure that strengthens a community.

Boulder is nestled in a beautiful, natural setting, surrounded by wildlife and stunning landscape. Much of the area outside of Boulder is managed by Boulder's Open Space and Mountain Parks. These open space trees, located as a buffer between Boulder and nearby development, provide many ecosystem services to the region. These trees are part of natural forest areas, largely outside of Boulder's city limits. As such, for the purpose of this UFSP, the Open Space and Mountain Parks trees are not considered part of the urban forest.

The map to the right shows tree canopy (green) across the City of Boulder. Canopy on Open Space and Mountain Parks properties (gray) are not managed by Boulder Forestry.

Map 2: Canopy in Boulder and Open Spaces and Mountain Parks



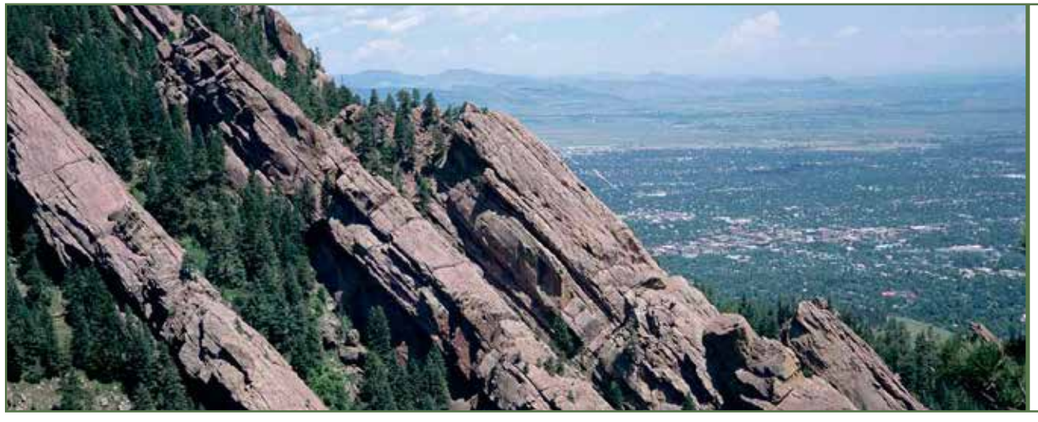
Parks and Public Plaza Trees?
Included in the UFSP.

The park trees and public plaza trees found on city-owned property, such as those around Evert Pierson Kids' fishing pond, are the responsibility of the Boulder Foresty. These trees are included in the urban forest.

Street Trees?
Included in the UFSP.

The urban forest includes street trees found on tree lined avenues. The trees in the public streets rights-of-way are the responsibility of Boulder Forestry.

Open Spaces and Mountain Parks Trees?
Not included in the UFSP.



For the purpose of the UFSP, the many beautiful trees in the open space and mountain parks that surround Boulder are considered their own separate entity. As such, they are not included in the calculations of ecosystem services or urban forest metrics.

History of Urban Forestry in Boulder

As Boulder's population grew from its incorporation in 1871, city leaders developed strategies to manage growth and preserve historic and natural resources. In 1959, Boulder voters approved the "Blue Line" city-charter amendment, which restricted city water service to altitudes below 5,750 feet to protect the scenic flatirons from development.

In 1961, residents overwhelmingly voted in favor to establish the Boulder Parks and Recreation Department (BPRD). Today, BPRD manages more than 1,800 acres of urban parkland.

Boulder's dynamic climate, which includes high-speed wind events, drought, drastic temperature drops, and high summer temperatures, limits the palette of tree species that can be grown in the community. In addition, recent large-scale snow storms and unseasonable freeze events have caused tree damage to species thought to be adapted to the area.

Due to the unique climate of the Front Range, there are few naturally occurring native trees, and most heritage trees in the community are the legacy of ranches and early settlements. Riparian areas have some native vegetation such as cottonwoods and boxelder, but also include substantial populations of naturalized species, such as green ash.

Over time, community tree planting has significantly added to the tree resource, where it is important to acknowledge that these trees would not thrive without the care of adjacent property owners and city staff. Because 92 percent of all trees are on private property, it is critical that the community is educated and motivated to provide for their trees.

In the 1970s, Dutch Elm Disease (DED), an invasive pathogen, spread rapidly through the urban forest, resulting in the removal of over 1,000 public elm trees. The sudden decline of elms necessitated the first systematic tree removal program beginning in 1972.

Following the hiring of the first city forester in 1973, an outbreak of Mountain Pine Beetle hit in Boulder's open space and mountain park areas. Several in-house crews were mobilized to address the outbreak. Once the threat dissipated, crews transitioned to providing care for all public street and park trees.

By 1975, Boulder Forestry had a crew of three full-time staff as well as two field crews tasked with removing elms and other dying street trees. A tree planting program was established and focused on increasing the diversity of species in the public urban forest. Staff used a city-owned sawmill to mill logs from elm and pine removals.

Wood was used in city projects as well as being sold as lumber, firewood, and other wood products.

By 1982, the management of DED was mostly under control through removals, sanitation, and enforcement. With a decrease in removals and an increasing availability of private arboriculture services, Boulder Forestry production staff was dismantled and replaced by contractual labor.

By the late 1980s, Boulder had employed a city Forester and two full-time Forestry Assistants to manage the growing needs of the urban forest. As a result, the first inventory of public trees was collected in 1987.

In the early 1990s, gypsy moth, another invasive tree pest, was found and promptly controlled with a biological control agent sprayed from helicopters in collaboration with the Colorado State Forest Service. Around the same time, the first tree safety inspection list was created by a contractor due to an increasing number of tree failures. The program continues to monitor trees.

An urban forestry modeling strategy was developed by Boulder Forestry to quantify maintenance requirements and costs based on species and relative age distribution. Trees and forests go through several developmental stages: Planting, Establishment, Growth, Structure, Mature, Overmature, and Replacement (PEGSMOR).

Urban foresters use the concept of PEGSMOR to understand the needs of a tree over its lifespan. Based on the model's projections, additional budget and forestry staff resources were allocated to help manage damages from storms and emerging pests and to further enhance Boulder's urban forest.

In 2015, the City of Boulder was identified as one of the Rockefeller Foundation's 100 Resilient Cities. This designation provided extra funding and resources for the city to work with multiple community planning organizations. Through a partnership with Trimble and DigitalGlobe, the city developed an initial geographic information system (GIS) land cover data layer that identified tree canopy, water, and impervious and pervious surfaces. Boulder has achieved Tree City USA status from the Arbor Day Foundation for 33 years.

Today, Boulder Forestry includes seven full-time employees; a city Forester, a Forestry Field Operations Supervisor, three Assistant Foresters and two Forestry Field Technicians. The division annually hires two to three seasonal employees and is responsible for the direct management of approximately 50,800 city park and public street ROW trees. The division also manages many external contractual services.

Historical Timeline

- **1961** - Residents voted in favor to establish the Boulder Parks and Recreation Department.
- **1973** – First city forester hired in response to Dutch elm disease removals.
- **1975** - A tree planting program was established and focused on increasing the diversity of species in the public urban forest. Staff used a city-owned sawmill to mill logs from elm and pine removals.
- **1987** – The first inventory of city and park trees was collected.
- **1990** – Gypsy moth, another invasive tree pest, was found and promptly controlled with a biological control agent (Bt) sprayed from helicopters in collaboration with the Colorado State Forest Service.
- **1991** - The tree safety inspection program was created due to the number of silver maple failures.
- **2002** – Drought conditions led to severe stress in the urban tree population.
- **2013** – EAB Detected
- **Today** - Boulder Forestry includes 7 full-time employees and manages approximately 50,800 public trees.

Damage caused by Dutch elm disease.

The tree safety inspection program (TSIP) at work.

An adult emerald ash borer.

Guiding Principles and Regulatory Framework

City policies and regulations provide the foundation for the Boulder urban forestry program. They outline requirements and specifications for the planting, installation, and care of Boulder's public trees and provide the regulatory framework for the protection and preservation of the urban forest assets. In addition, city policies and regulations provide the enforcement framework of activities and issues that impact the community's trees.

The development of Boulder's Urban Forest Strategic Plan included a comprehensive review of guiding documents, local policies, development and construction standards, ordinances, and other regulations that apply to the urban forest.

It is important to note that although all the following plans set goals, guidelines and priorities for forestry, they do not provide additional funding, staff or partnerships to accomplish them. They also do not address what may be perceived as trade-offs, such as more canopy could result in less opportunity for solar. Or higher development costs for public and private development if there are more tree requirements and restrictions. A solid review of plan integrations with consideration to funding and priorities is explored in the recommendations of the UFSP but will require departmental and community buy-in to be successful.

The following plans also had extensive outreach and public engagement as part of their development, ensuring they reflect community vision and preferences. The following provides a summary of the review process and key findings.

Boulder Valley Comprehensive Plan

The Boulder Valley Comprehensive Plan (BVCP) provides a general statement of the community's desires for future development and preservation of the Boulder Valley. The principle of sustainability drives the overall framework of the BVCP. Core components provide guidance for growth and development. This guidance includes preservation, economic development, environmental protection, transportation, neighborhood character, and urban design and land use.

Vision

"The Boulder Valley community honors its history and legacy of planning for a livable community surrounded by open space and rural lands while striving together to create and preserve a truly special place that is sustainable, resilient, equitable and inclusive - now and for future generations."

Core Values

Core values represent long-standing community values and a clear vision of Boulder's commitment to quality of life issues, including those supported by the Urban Forest Strategic Plan:

- **Sustainability** as a unifying framework to meet environmental, economic and social goals;
- A welcoming, **inclusive and diverse** community;
- Culture of creativity and **innovation;**
- Strong **city and county** cooperation;
- Our unique community **identity and sense of place;**
- **Compact, contiguous** development and infill that supports evolution to a more **sustainable urban form;**
- **Open space** preservation;
- Great **neighborhoods** and **public spaces;**
- **Environmental** stewardship and **climate** action;
- A vibrant **economy** based on Boulder's quality of life and economic strengths;
- A diversity of **housing** types and price ranges;
- An all-mode **transportation** system to make pedestrian mobility more accessible; and
- Physical **health, safety and well-being.**

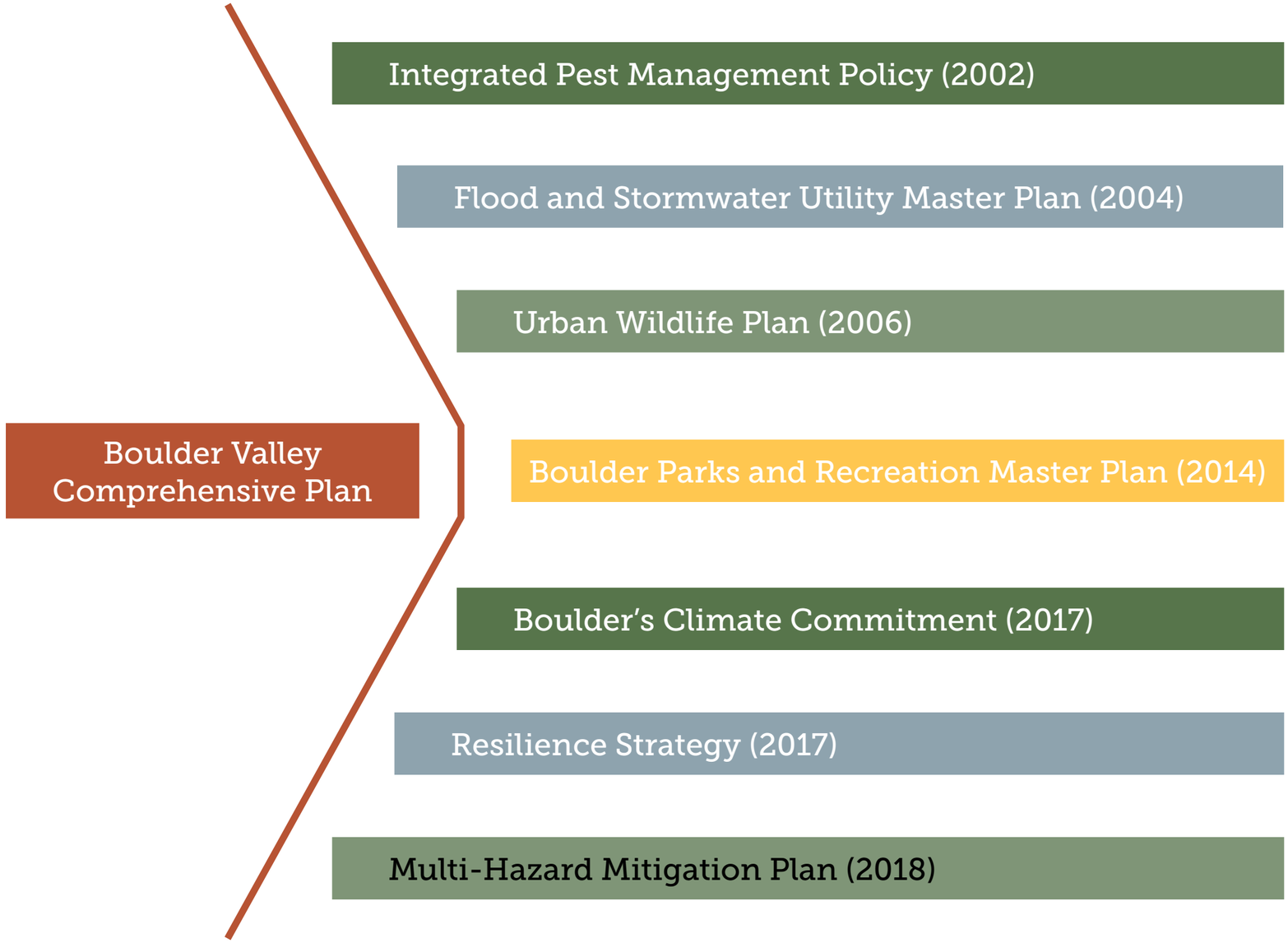
Departmental Master Plans are developed to be consistent with the Comprehensive Plan. They establish detailed policies, priorities, service standards, facility and system needs and capital budgeting for the delivery of specific services provided.

The Boulder Valley Comprehensive Plan policies guide decisions about growth, development, preservation, environmental protection, economic development, affordable housing, culture and arts, urban design, neighborhood character and transportation. The policies also inform decisions about the manner in which urban services are provided, such as police, fire, emergency medical services, water utilities and flood control.

Urban Forest Strategic Plan Implications

The BVCP is the unifying document that creates a cohesive whole from many other plans. Because of this, all urban forest strategies and management practices should be designed to be congruent with other plan goals. Often, there is opportunity for synergy. For example, the urban forest can serve as a tool to Boulder's climate commitment through lessening energy demand.

The BVCP is built on the framework of sustainability and resilience. A sustainable urban forest is well-managed, designed for the long-term, and healthy. A resilient urban forest has a diverse species composition and proactive maintenance. To attain these sustainable and resilient traits, Boulder must commit adequate funding to conduct the core programs and responsibilities necessary for optimal tree care.



Boulder Parks and Recreation Master Plan

The 2014 Boulder Parks and Recreation Department (BPRD) Master Plan established a five-year plan to identify short-term strategies to build success over the long-term. The BPRD Master Plan is guided by principles that include sustainable practices, health, partnerships, and service excellence. A clear mission and vision statement clarify the intent of the plan:

BPRD Mission

"Boulder Parks and Recreation Department will promote the health and well-being of the entire Boulder community by collaboratively providing high-quality parks, facilities and programs."

Vision

"A community where everyone's health and well-being is founded on unparalleled parks, facilities and programs."

Key themes, which emerged from research and community engagement, shaped the six strategies that are the focus for the future action and decision-making outlined in the BPRD Master Plan.

- **Taking Care of What We Have**

  The trees of the urban forest serve as living infrastructure for Boulder. This infrastructure provides numerous benefits, and so the maintenance and growth of the urban forest is vital and embodies the BPRD theme of Taking Care of What We Have.

Case Study: Neighborhood Tree Stewards

Since 1997, the Neighborhood Tree Steward (NTS) program has worked with Portland, Oregon community members to provide nearly 300 people with the tools and resources to be active leaders and urban forest promoters in their neighborhoods. Participants enroll in a seven-session course (21-22 hours) that covers topics including tree biology, identification, pruning and maintenance, proper planting techniques, ecosystem services, pests and pathogens of the urban forest, and urban forest management and policy. As of 2017, the course includes an environmental justice component to address urban forest equity. The cost to attend is $26, which includes the NTS hoodie participants receive on completion of the course. Participation in all 7 courses is required, but related substitute events can qualify as credit.

No previous experience is needed to become a Neighborhood Tree Steward, but participants usually have a passion for trees, a desire to learn, and a commitment to help. The NTS curriculum has developed over time based on feedback from student surveys, and availability of guest speakers. Curriculum is reviewed and updated annually. Staff from the non-profit along with professional volunteers, teach these courses. Once the course is completed, NTS graduates are asked to contribute 40 hours of tree-related volunteer service over the next year. Participants fulfill this service requirement by participating in urban forestry workshops, serving on the Heritage Tree Committee, teaching kids about trees at a Learning Landscapes event, organizing a community tree planting, or representing Neighborhood Tree Teams at Neighborhood Association Meetings.

Key Concepts:

- Provide opportunities for volunteers to take on leadership roles.
- Build a team of engaged advocates.
- Understand the community's unique urban forestry challenges and opportunities.
- Participants use their knowledge to provide community service and urban forest outreach.
- Develop strategies to remove barriers to participation for all community members.
- Trainees become advocates for the urban forest armed with knowledge of area trees, policies, and threats.

- **Community Health and Wellness**

  The urban forest cleans the air, moderates extreme temperature, and provides mental and physical health benefits. A thriving urban forest supports the BPRD theme of community health and wellness. In addition, effective management of the urban forest creates a safe environment for residents and visitors.

- **Financial Sustainability**

  Optimized maintenance programming and species selection for trees in the urban forest will help balance costs with returns and minimizing volatility in budget demands. Thus, forward thinking and proactive maintenance supports the BPRD theme of financial sustainability.

- **Building Community and Relationships**

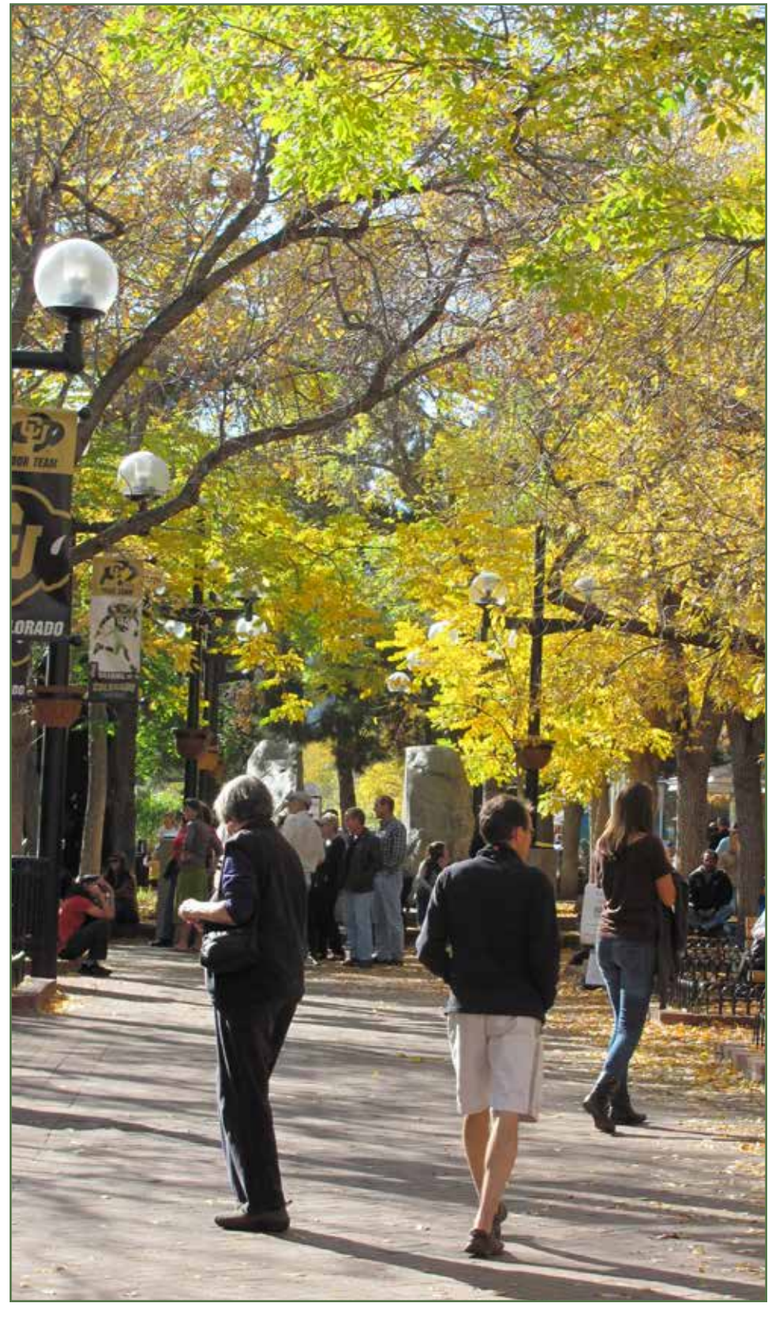
  A successful urban forest and urban forestry program builds communities and relationships in two major ways. The first is by providing safe and desirable spaces where the community feels relaxed to interact with each other. The second is through the direct involvement of community members by bringing together numerous organizations and individual volunteers together for planting parties, tree nature walks, fundraising, and other urban forestry activities.

- **Youth Engagement and Activity**

  The urban forest provides a rich opportunity for collaboration with school systems to educate and engage the youth with outdoor activities. Further, activities such as trail maintenance and tree plantings serve as potential volunteer projects. In addition, the urban forest provides fun, safe, and comfortable places to play and study.

- **Organizational Readiness**

  A key component of urban forest management is emergency response. Improved processes, staff training, communication, and coordination will foster efficient organizational readiness.



Plan policies that are especially relevant to the development of the Urban Forest Strategic Plan include:

- BPRD shall ensure adequate resources are available to maintain and operate assets within community sustainability goals.
- An asset management system that tracks; asset condition, critical systems maintenance and repair and rehabilitation requirements, will be implemented and used in making park and facility investment decisions.
- The proposed development of any new park and facility shall be evaluated through a feasibility study that includes a Needs Assessment, user profile, projected participation analysis, development funding method, life cycle cost pro forma and alternative development trade-off analysis.
- BPRD shall seek and develop partnerships and opportunities to leverage maintenance and capital building funds.
- BPRD shall ensure that the department workforce, structure, and culture are designed and prepared to respond to community needs.
- BPRD shall develop a highly effective workforce that will positively impact the community's health and quality of life.

As part of the background research for the 2014 BPRD Master Plan, a Needs Assessment was conducted in 2014 to analyze the existing services provided by the BPRD to Boulder in the following areas: parkland, recreation facilities and recreation programs and services. Agencies

Case Study: TreePhilly

Since 2012, TreePhilly, a program of the Philadelphia Parks and Recreation Department, has provided over 17,500 trees to more than 8,000 residents. The yard tree program was the result of a partnership with the Fairmount Park Conservancy to provide trees for private property plantings. The trees are distributed to registered participants with mulch bags. The trees stock are 5-gallon grow-bags with handles to facilitate ease of transport and planting, and participants have a demonstration of proper tree planting from city arborist staff and trained volunteers at the time of pick up. Additional information is provided through an online video library, and through a Yard Tree Planting and Care guide which is available for download.

Over the past six years, the program has been improved to increase inclusion, and streamline tree procurement. For example, Tree Philly offers free delivery and planting for residents with limited mobility through a simple application process which is requested wo to five times per year. Those trees are delivered and planted by the nursery which grows the tree stock from liners. Since the program is within the Philadelphia Parks and Recreation Department, tree purchasing originally went through the city procurement office, which added layers of complexity. Over time, staff developed a good working relationship with a local nursery, and today, they provide all the trees, as well as delivery to each neighborhood event. Tree Philly Staff provides a tree list one year in advance, and the nursery produces the stock. The tree price is approximately $25 per tree to the city (free to program participants).

The yard tree program is managed by one full time employee and two seasonal (nine-month) staff. Each event requires about 20 volunteers. Volunteer recruitment and training is provided by the Pennsylvania Horticultural Society Tree Tenders program. Initially, the program was publicized through flyers, attending community meetings and press releases. Today, most participants find out by word of mouth. Neighbors have begun to see tree distribution days as recurring community events which are now an expected city service. A brief email survey is sent to all participants to check on the tree at the time of establishment.

Key Concepts:

- Grow canopy on private property by providing training, mulch and free trees;
- Address concerns about city assets on private property by securing program funding from an outside source; and
- Requests for trees are made online and distributed en masse at neighborhood events to facilitate easy transport.

track services as a way to meet the needs and desires of citizens. This tracking also helps maintain a desired state while taking land use goals, as well as limited financial and human resources, into consideration.

The Needs Assessment analyzed parks by the four categories defined by BPRD:

- Neighborhood parks;
- Community parks;
- City and regional parks; and
- Other land types.

Parks in Boulder have 122 acres of tree canopy. BPRD has nearly 717 acres currently developed for public use.

Urban Forest Strategic Plan Implications

Because many urban forest trees are located in Boulder parks, the components of this plan have many implications for urban forest management. The key themes addressed in the BPRD Master Plan highlight the opportunity for community outreach and volunteer events. Effectively sharing city resources such as equipment and staff can help maximize departmental goals while reducing overall city expenses. The parks plan also facilitates the definition of departmental roles in the management of the urban forest.

Case Study: Colorado Solar Gardens

Colorado Solar Gardens allow customers to buy shares in a solar array, and receive annual savings. Over 20 solar gardens were built in Colorado through an Xcel Energy Pilot program, including two in Boulder: the Clean Energy Collective and Community Energy Solar.

In Xcel Energy's Colorado territory, solar gardens can be anywhere from 10 kilowatts, which would fit on a large roof, to 2 megawatts, requiring up to 16 acres. An average single-family home would offset 100 percent of its electricity usage with about 2-5 kilowatts of solar power. There are different ways to participate in a solar garden, in one case, community members invest up front and save on their energy bill.

One-kilowatt shares cost $3,700 and save $270 per year. In other cases, subscribers purchase or lease shares in a solar garden operation offered by a nonprofit, municipality, or solar developer. The maintenance and operation of the solar garden is provided by the operator, and credits are distributed as reductions in monthly Xcel Energy bills. In Colorado, at least 5 percent of solar garden subscribers must be low income.

Recognizing that solar gardens provide a solution to urban forest versus solar conflicts, the city can facilitate outreach for the participation in solar gardens. Boulder has attained the Solar Friendly Communities recognition, which demonstrates the city's commitment to solar energy. Neighborhood services provides information to residents about opportunities to join solar gardens.

Key Concepts:

- Provide opportunities to participate in solar energy for all, including renters and those with homes and businesses shaded by trees;
- Maintain urban forest canopy, and place solar arrays in appropriate facilities that are easily maintained; and
- Reduce barriers to entry with relatively low-cost share options.

Flood and Stormwater Utility Master Plan

Stormwater and Flood Management Utility is responsible for the administration of the city's flood management, stormwater quality, and stormwater drainage programs. Because trees and canopy play a role in stormwater management, the development of the UFSP included consideration that outline:

- System master planning and design;
- System maintenance and restoration;
- Flood prediction;
- Stormwater quality management;
- Emergency preparedness; and
- Capital improvements and land management.

Guiding Principles

Using national and regional trends and philosophies, as well as current and past local policies, staff recommends five guiding principles:

- Preserve floodplains;
- Be prepared for floods;
- Help people protect themselves from flood hazards;
- Prevent adverse impacts and unwise uses in the floodplain;
- Seek to accommodate floods, not control them; and
- Implications for the Urban Forest Strategic Plan.

Urban Forest Strategic Plan Implications

The urban forest is a key component in flood and stormwater management. Trees and vegetation minimize the severity of flooding from storm events by intercepting rainfall in the canopy. This reduces soil erosion and improves stormwater quality.

Green infrastructure principles can be applied to tree planter designs to minimize stormwater runoff. The Flood and Stormwater Plan also relates to urban forest management by defining clear departmental roles in emergency events.

Boulder Resilience Strategy

The Resiliency Strategy provides approaches for Boulder to strengthen preparedness for future challenges. These challenges include relevant shocks like flash flooding, sudden freezes, or wildfires. The Resiliency Plan is built on three core strategies: connecting and preparing, partnering and innovating, and transforming and integrating. The vision of the Resiliency Plan is:

"Building on a legacy of innovation, Boulder will cultivate a creative spirit to adapt to and thrive in a changing climate, economy and society."

Urban forests supply multiple cultural and ecological services and are therefore often cited as a tool for building urban resilience to the effects of climate change. Urban forests reduce negative climate change

impacts, enabling cities to absorb greater disturbance while maintaining their essential structure and function and supporting the wellbeing of residents (Hartman, 2016).

Citizen Science Project

Boulder is one of the first 32 cities chosen to participate in 100 Resilient Cities (100RC). The program, pioneered by the Rockefeller Foundation, is funding 100 chief resilience officers in selected cities worldwide. 100RC is a global network pioneered by the Rockefeller Foundation to help cities around the world become more resilient to the physical, social, and economic challenges of the 21st century. Boulder joined the network as part of the initiative's first wave in 2013, and through its participation, is committed to demonstrating leadership in resilience as well as leveraging resources and opportunities.

Urban Forest Strategic Plan Implications

Resiliency is a fundamental component of effective urban forest management. This is accomplished through two primary categories: preparation and response. In preparation, tree species should be selected from a diverse range to mitigate the potential impact of severe weather events, pests, and other threats. For response, clearly defining departmental roles and lines of communication during and post emergency events will increase service effectiveness and lower overall response time.

Multi-Hazard Mitigation Plan

The purpose of the hazard mitigation plan is to reduce or eliminate long-term risk to people and property from natural hazards and their effects in Boulder. The city is vulnerable to several natural hazards that are identified, profiled, and analyzed in the plan. Floods, wildfires, and severe weather are some of the hazards that can have a significant impact on the city. The plan categorizes the urban forest as major capital assets in Boulder.

The Multi-Hazard Mitigation Plan has three goals:

- Raise awareness of Boulder's natural hazards;
- Reduce vulnerability to natural hazards; and
- Increase interagency coordination to reduce the impact of natural hazards

The plan notes several areas and examples of events that have harmed trees, including the 2002 drought that damaged trees and resulted in unexpected pruning and removal costs estimated at over $120,000. The plan recommends an eight-year pruning rotation, which would make trees stronger and more resistant to storm, freeze, and snow damage, thus reducing post-storm cleanup costs and liability exposure.

In addition to recognizing the environmental services created by the urban forest, the plan also details the valuable role the urban forest plays in flood control. Boulder's urban forest reduces stormwater runoff by approximately 12.2 million feet per two-inch storm event (enough water to fill Folsom Field, the university's football field, several times). The plan also recommends increasing Urban Tree Canopy in commercial areas by 2 percent and in residential areas by 4 percent.

A valuable component of the plan is to make the City of Boulder eligible for certain federal disaster assistance, specifically, the Federal Emergency Management Agency's Hazard Mitigation Grant Program, Hazard Mitigation Assistance grant program and Pre-Disaster Mitigation program. These federal assistance programs can be valuable resources for unexpected urban forest challenges.

The full plan includes descriptions of actions, identification of alternatives, responsible offices, priority, cost estimates, estimated benefits, potential funding sources, and schedules.

Urban Forest Strategic Plan Implications

Much like the Resiliency Plan, the Multi-Hazard Mitigation Plan facilitates the defining of departmental roles and lines of communication during and post emergency events. This will increase service effectiveness and lower overall response time.

"The trees that make up the urban forest are also considered major capital assets in the city."

~Multi-Hazard Mitigation Plan

Forest Ecosystem Management Plan

In June of 1999, Boulder City Council approved Boulder's Forest Ecosystem Management Plan (FEMP) to manage lands under the jurisdiction of Boulder's OSMP. The plan established a framework, policy guidelines, and management direction for forest ecosystem management on city lands. The FEMP focuses on two primary goals:

- Maintain or enhance native plant and animal species, their communities and the ecological processes that sustain them; and
- Reduce the wildfire risk to forest and human communities.

Urban Forest Strategic Plan Implications

It is important to note that the OSMP trees are not included as part of the urban forest within the context of the UFSP. The open spaces and mountain parks form a buffer around the city, helping to establish their own, separate identity from neighboring communities and provide their own set of ecosystem services. These trees are not included when conducting Boulder's urban forest inventory or calculating ecosystem benefits from the urban forest. There are still many valuable opportunities for education and collaboration with OSMP to collect data, conduct staff training, share information, evaluate ecosystem services, and collaborate for education and outreach.

Climate Action Plan

Boulder's Climate Action Plan (CAP) is a set of proactive, city-funded programs that target the reduction of local greenhouse gas emissions. In 2002, Boulder City Council passed a resolution encouraging the community to reduce its greenhouse gas emissions to levels identified by the Kyoto Protocol. In 2009, the city's voters became the first in the country to pass a tax to reduce greenhouse gas emissions and address the impact of human activity on climate change (the CAP tax).

The four Action Areas for the 2017 city's Climate Commitment are:

- Energy;
- Resources;
- Ecosystems; and
- Community climate action.

The Ecosystems Action Area is relevant to the urban forest and relates to the ability of urban, wildland, and agricultural ecosystems to capture and stabilize atmospheric carbon and provide critical buffering against climatic extremes. Urban forestry priorities include increasing the number of local trees and green infrastructure to increase urban tree canopy for the long-term. Key aspects of the strategy are community education, tree plantings, supporting local green nonprofits, and tree maintenance.

Urban Forest Strategic Plan Implications

Trees are a key component to mitigating climate change. Trees in the urban forest are living infrastructure that directly strengthen the city's climate action plan. By providing shade and blocking cold winds, trees normalize building temperatures and reduce energy use. Trees also absorb carbon dioxide through photosynthesis and filter the air we breathe.

"Research indicates that healthy trees can mitigate a range of environmental impacts, including stormwater runoff, poor air quality and temperature extremes. Trees also provide significant energy use reductions associated with both cooling and heating...

...The City of Boulder's urban forest and ecosystems are an integral part of its living infrastructure."

~Climate Action Plan

Boulder's Climate Commitment

The 2017 Climate Commitment articulates the following vision for the urban forest:

"By 2050, Boulder's urban landscape will be planted with trees and plants that can moderate climate extremes, reduce energy, and water use, improve water quality, and enhance the beauty and livability of Boulder's urban environment... More than 20 percent of the land area in the developed portions of Boulder will be shaded by trees … By increasing the number, diversity and placement of trees in Boulder's urban centers, we will improve air and water quality, reduce building heating and cooling needs, and mitigate the visible loss of hundreds of thousands of ash trees in our community."

Urban Forest Strategic Plan Implications

The Commitment contains the following priorities:

- Maintain the existing urban tree canopy;
- Monitor the urban forest using both on-the-ground and remote sensing technologies to document how it is responding to climate change. Establish ongoing monitoring protocol;
- Increase the diversity of urban tree species to improve overall urban forest resilience;
- Review and improve strategies for pest and disease invasions, including EAB;
- Review and refine park and natural space plans to minimize damage from the impacts of increased use and warmer conditions;
- Explore the establishment of a partner, non-profit urban forest foundation to provide additional financial and community support;
- The city and county will strive to preserve and protect the natural resource base by:
  - Maintaining and enhancing the biodiversity and productivity of ecological systems;
  - Ensuring the efficient use of natural resources that does not deplete them over time
  - Reducing and minimizing the use of non-renewable resources; and
- Review and revise enforcement of canopy goals and parking lot shading guidelines.

Urban Wildlife Management Plan

The Urban Wildlife Management Plan (2006, 2011) (UWMP) establishes a set of policies and procedures for managing wildlife, including species of special concern, within Boulder on both public and private lands. The purpose of the UWMP is to develop effective strategies to minimize human/wildlife conflicts and increase public awareness of how to better coexist with these animals.

The UWMP includes the Black Bear Component and Mountain Lion Component, both were approved in 2011, In addition, the Black-tailed Prairie Dog Component, was approved in 2006. The city's goals and the plan support and recommend the protection of animal species, not individual animals, and emphasize humane, non-lethal control of wildlife whenever possible.

Urban Forest Strategic Plan Implications

By minimizing forest fragmentation, wildlife corridors are preserved, resulting in a healthier ecosystem. It is also important for tree care professionals to identify when trees are currently being used as habitats. The city limits planting of true "fruit" bearing trees, such as pears and apples west of Broadway Avenue, since they are a Black Bear attractant.

Photo courtesy of Museum of Natural History, University of Colorado, Boulder

State Law

Pesticides

The Colorado Department of Agriculture (CDA) regulates the distribution and use of pesticides in the state to prevent adverse impacts to the public and the environment. Regulation includes licensing and inspection of all commercial and private pesticide applicators to make sure pesticide use, storage, and disposal comply with state and federal law. CDA also monitors pesticide sales and provides regulations for pesticide use near waterways, which requires a state permit (available online).

Emerald Ash Borer Quarantine

EAB is a federally quarantined pest. With the Boulder discovery of EAB in 2013, the CDA and USDA Animal and Plant Health Inspection Services imposed a quarantine on Boulder County and parts of Weld, Jefferson, and Larimer counties to slow the spread of EAB. The quarantine prohibits the movement of hardwood, firewood, and other ash tree stock and wood materials outside quarantined areas.

Municipal Ordinance and Policy

TITLE 6. CHAPTER 6 PROTECTION OF TREES & PLANTS establishes rules and regulations for the licensing of tree care professionals, provides tree removal mitigation requirements, and defines penalties for damage to trees in parks and unpermitted damage to street trees. In Boulder, all maintenance for public street trees, including planting, rotational pruning, pesticide applications, and removal, is the responsibility of Boulder Forestry. Adjacent property owners have the following opportunities and obligations:

- May contract with a licensed certified arborist to perform tree work such as pruning or the application of pesticides to a public street tree with authorization from the city forester; and
- Adjacent property owners must also water public street trees and provide a sod free base to avoid damage.

If a property is going to be developed or redeveloped, trees undergo a site review process including inventory, anticipated impacts, and plans for mitigation. Street trees are required to be planted in the public ROW at the time of development. On most sites, the designated spacing is one tree per forty linear feet, within ten feet of the pavement edge. The trees must be from the approved street tree list, or approved by staff on a case-by-case basis if unique circumstances are identified. The Planning Department regularly provides expert advice to ensure species planted are compatible with site attributes. Additional requirements for parking lots and open spaces are defined.

TITLE 6 protects trees in the ROW and on city-owned property, but the adjacent property owner can remove trees in the ROW if they obtain approval. Construction on city-owned property and public ROW and easements must provide tree protection in conformance with the Boulder Design and Construction Standards. To commercially prune trees for profit, an individual would need the proper licensing.

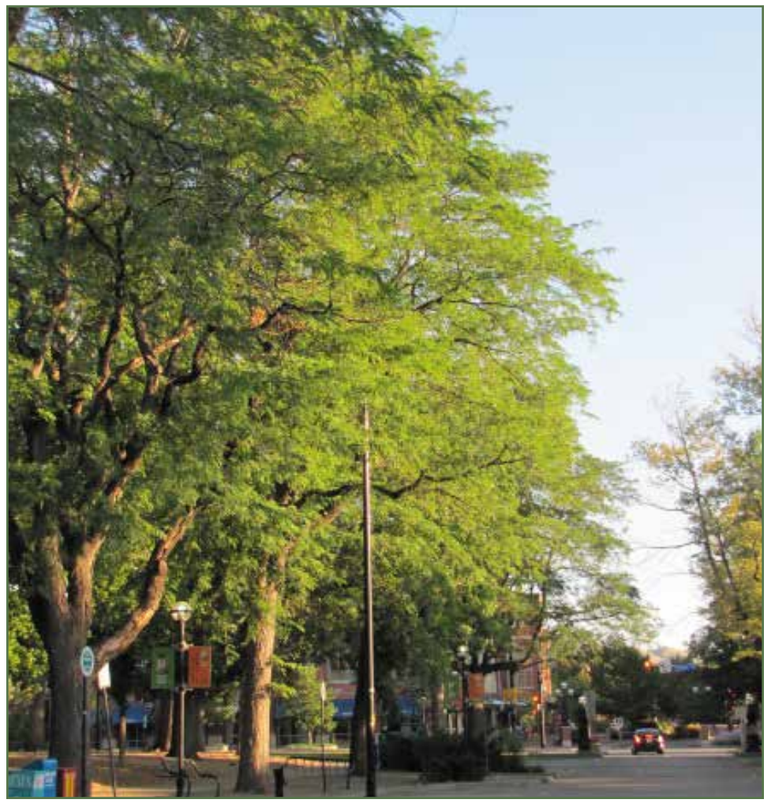
Code requires that when trees and plants in the ROW are removed or destroyed they shall be replaced with equivalent value as determined by city manager. If the location cannot support a new, equivalent tree, then Boulder will be reimbursed the appraised value of the tree.

TITLE 9. CHAPTER 9 LANDSCAPING AND SCREENING STANDARDS (Development Standards) requires a “sight triangle” where a driveway intersects a public ROW or where property abuts the intersection of two public ROW (unobstructed sight). Trees may be planted and maintained within the “sight triangle” area if all branches are trimmed to maintain a clear vision for a vertical height of ninety-six inches above the roadway surface and the location of the trees planted, based on the tree species expected mature height and size, does not obstruct sight visibility by more than twenty-five percent of the “sight triangle".

Landscape and screening standards in **TITLE 9. CHAPTER 9** also require a minimum of one tree per 1,000 square feet for public, outdoor, and landscaped open spaces. The trees must be planted in the ground or accommodated in tree vaults over parking garages. Parking lot screenings require at least one tree per 25 linear feet at property lines. There is a separate interior planting requirement of one tree for every 200 square feet of landscape area.

Streetscape improvements must meet several standards:

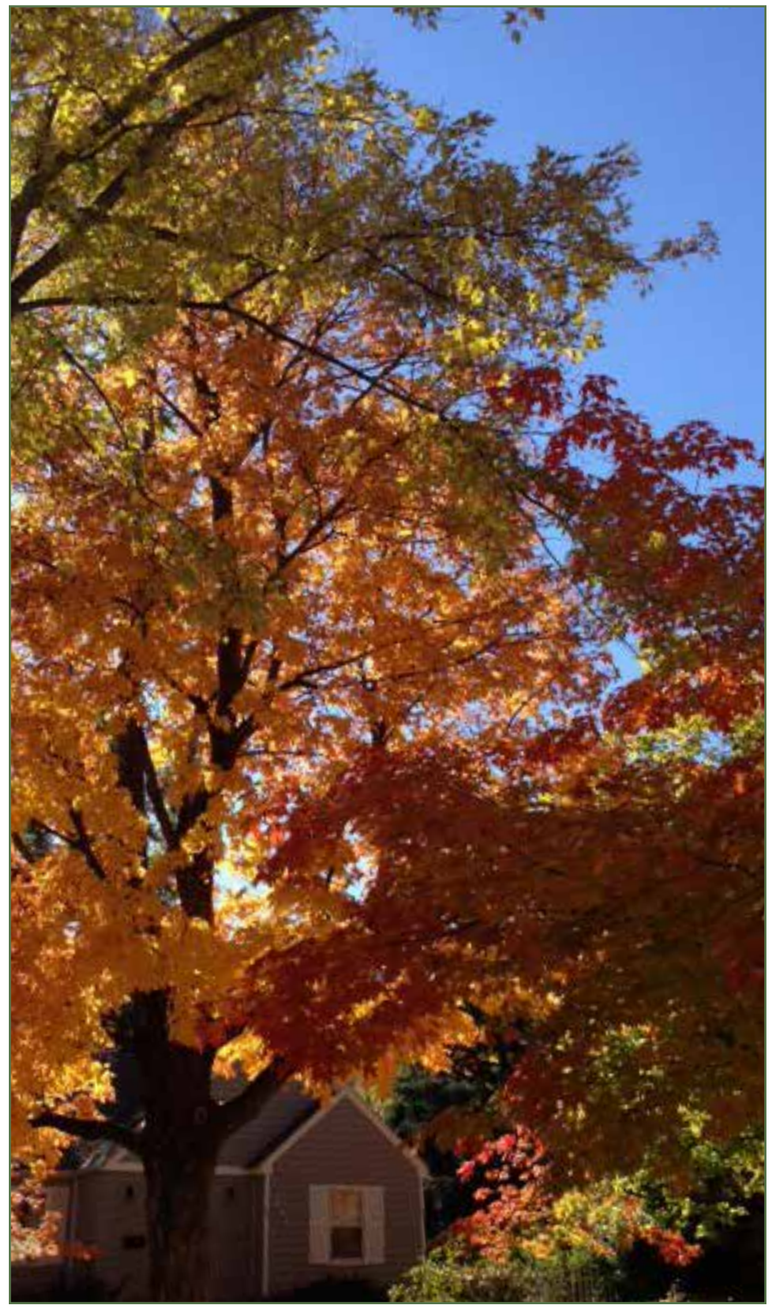
Street Trees: A planting strip consisting of deciduous trees shall be planted along the full length of all public and private streets in all zoning districts. When possible, trees shall be planted in the public ROW. Large deciduous trees and detached sidewalks are the preferred design elements.



Alley Trees: Except for existing single-family lots, trees shall be planted at an overall average of one tree per forty linear feet within ten feet of the pavement or edge of alley.

Streetscape Requirements: Street trees must be selected from the approved street tree list set forth in the Boulder Design and Construction Standards, unless an equivalent tree selection is approved by the city manager.

Boulder has developed an excellent, flexible matrix that communicates the required planting by the sidewalk site conditions and traits.



Case Study: City of Atlanta Regulation of Trees on Private Property

The City of Atlanta maintains clear regulations about tree removal on private property. Atlanta's tree ordinance was developed by a core group of urban forest stakeholders who began the process by considering tree protection options in Georgia and nationwide.

The process for ordinance development provided for public input, compromise and consensus. The strength of the regulation lies in it being equitably enforced, and having clear and unambiguous language. The ordinance includes definitions, grants specific authority and clearly describes penalties, and the appeals process. To measure the effectiveness of the ordinance, key metrics are tracked periodically.

These metrics include how many trees are preserved, fees paid, number of violations, and levels of public awareness. In Atlanta, these are measured annually the Arborist Division. Fees paid for violations fund a City Tree Trust which provides for future urban forest enhancement.

Key Concepts:

- Convene a group of stakeholders to develop regulations;
- Clearly establish applicability;
- Provide for public input, compromise, and consensus; and
- Grant specific authority for enforcement to a specific city agent.

TITLE 9. CHAPTER 12 SUBDIVISION indicates that each subdivision plant lot must contain at least one deciduous street tree of two-inch caliper in residential subdivisions, and each corner lot contains at least one tree for each street upon which the lot fronts, located so as not to interfere with sight distance at driveways and chosen from the list of acceptable trees established by the city manager.

TITLE 9. CHAPTER 9 SOLAR ACCESS establishes the principles, applicability, and organization of solar energy access. The section applies solar access codes to all city property and all private property and developments. Government organizations not under the jurisdiction of the city may opt in unless provided an exemption by the city manager. Three solar access zones are established and organized into groups based on density, topography, and lot orientations.

These are areas SA Area I, SA Area II, and SA Area III. Each area has its own protections for solar entry based on hypothetical shade height between two hours before and two hours after local solar noon on a clear winter solstice day. SA Area I is protected from shading 12 feet high, SA Area II is protected from twenty-five feet high, and SA Area III receives no protection.

TITLE 9.CHAPTER 2 SITE REVIEW establishes siting and construction requirements to ensure maximum potential for utilization of solar energy. In the city, applicants for residential site reviews shall place streets, lots, open spaces, and buildings so as to maximize the potential for the use of solar energy in accordance with criteria, including landscaping. The shading effects of proposed landscaping on adjacent buildings must be minimized. Boulder has a vision committed to establishing trees and increasing solar energy generation. The code is flexible to achieve harmony between solar panels and trees.

TITLE 6. CHAPTER 1 BIRD PROTECTION SANCTUARY CREATED establishes that the area within the city is declared to be a sanctuary for the refuge of protected birds. Urban wildlife in Boulder is protected, including birds, prairie dogs, bears, and bees. The city requires permits for any injury or killing of protected urban wildlife and works diligently with property owners to identify non-lethal solutions to wildlife conflicts.

TITLE 8. CHAPTER 3 WILDLIFE PROTECTION states that no person shall hunt, trap, net, impede, harass, molest, chase, kill, or remove any wildlife or livestock or damage, destroy, or remove any nest, burrow, or animal dwelling from any park, recreation area, or open space or other property of the city, including any ROW controlled or maintained by the city.

TITLE 6. CHAPTER 10 PESTICIDE USE (Boulder's Pesticide Ordinance) requires that Boulder residents be notified when and where pesticides are applied. It is the responsibility of the pesticide applicator to notify all adjacent property owners at least 24 hours prior to airborne application. Boulder's Integrated Pest Management Policy extends that notification requirement for city applications to include all pesticide applications – airborne, ground, and trunk/soil injected. Once notified, application must occur within seven days.

TITLE 5. CHAPTER 9. SECTION 7 UNREASONABLE NOISE PROHIBITED BETWEEN THE HOURS OF 9 P.M. AND 7 A.M.-- LAWN MOWERS, LEAF BLOWERS, AND CONSTRUCTION allows exemptions for equipment used to remove flood debris, which extends the operating hours to 5:00am - 12:00am.

TITLE 8. CHAPTER 5 TEMPORARY TRAFFIC CONTROL specifies that no person shall perform work (including tree maintenance) in the ROW without providing temporary traffic control measures. These requirements are intended to enable safe passage for Boulder residents on public ROW and are an important consideration for any tree care personnel when developing work plans for all tree care maintenance activities.

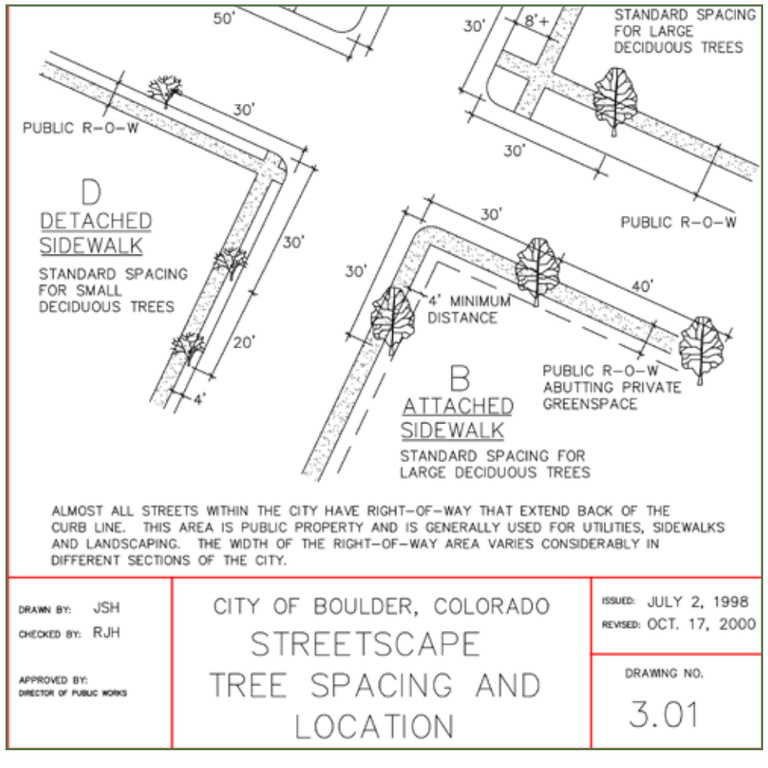
Urban Forest Strategic Plan Implications

Municipal ordinances impact the urban forest by defining tree-related responsibilities for private property owners, real estate developers, and tree care companies. Specific requirements, such as the number of trees required for a new development, can be altered by Boulder leadership to increase the tree population and expand the urban tree canopy.

Design Standards

CHAPTER 3 OF BOULDER'S DESIGN AND CONSTRUCTION STANDARDS: Streetscape Design and Tree Protection is intended to improve public safety by preventing sight distance and facility obstructions and sidewalk and street damage, to promote suitable landscape species selection for streetscapes, to minimize tree and landscape maintenance costs, and to create an aesthetic community image through continuity.

The standards identify requirements for the selection, placement, and removal of trees on construction sites and provide requirements for tree protection and general landscaping and maintenance.



A key component to tree protection is the requirement that applicants applying for construction projects where streetscaping improvements will be included must submit a landscaping plan in compliance with these Standards and those set forth in TITLE 6 CHAPTER 6 (PROTECTION OF TREES AND PLANTS), TITLE 9 CHAPTER 2 (REVIEW PROCESS), AND CHAPTER TITLE 9 CHAPTER 5 (SUBDIVISIONS). This plan must include elements to protect trees; design details and notes, construction activity controls and measures, and any necessary provisions or restrictions to ensure the protection of existing trees.

While the standards state that trees shall only be removed in compliance with a landscaping plan approved by the city, this is not always the case. Currently, there is a loophole for tree removal, where the owner/developer simply removes trees prior to permitting.

Urban Forest Strategic Plan Implications

Design standards play a crucial role in the development of an urban forest because they define the geographic and spatial environment for trees. For example, soil volume requirements impact the probability of a tree developing into a healthy mature plant. City staff should include arborists in the design process when standards are updated to maximize the opportunity for trees to succeed in urban environments.

Federal Wildlife Regulations

The **Federal Migratory Bird Treaty Act** protects all common wild birds found in the United States except for house sparrow, starling, feral pigeon, and resident game birds, such as pheasant, grouse, quail, and wild

turkeys. The Migratory Bird Treaty Act makes it unlawful for anyone to kill, capture, collect, possess, buy, sell, trade, ship, import, or export any migratory bird, including feathers, parts, nests, or eggs.

The **Federal Endangered Species Act** makes it illegal to sell, harm, harass, possess or remove protected animals from the wild.

Urban Forest Strategic Plan Implications

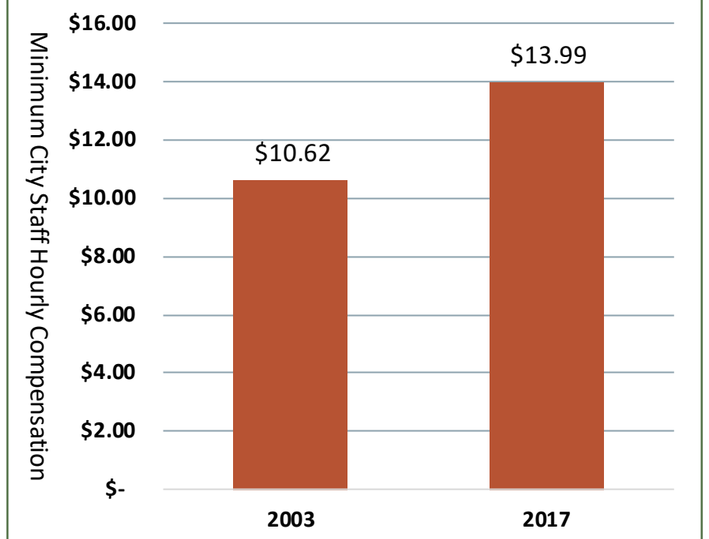
By practicing mindful tree maintenance practices, disturbances or accidental injury to protected wildlife and their habitats are minimized.

Living Wage Regulations

Colorado state law currently prohibits local government from establishing a citywide minimum wage. The statute does not restrict local governments from establishing policies that address the wages they pay to employees or contractors. Without the option of establishing a minimum wage across the board for all workers in the community, City Council opted in 2003 to adopt Resolution 926, which directed the city manager to pay the city's standard full-time employees no less than 120 percent of the Federal Poverty Guidelines (Chart 3). In 2003, when the Resolution was implemented, the wage was $10.62 per hour. Now, the minimum wage was adjusted each year, where it reached $13.99 in 2017.

In February 2016, Resolution 926 expanded to other categories of city employees, including part-time and temporary. In 2017, the approved city budget included increased funding for an expanding living wage for city employees, janitorial and landscape contractors, and emergency medical services (EMS) ambulance providers. The 2017 Budget included funding to increase wages rates for contracted janitorial and landscaping service providers, as well as for EMS ambulance service providers, to a minimum rate of $15.67 per hour.

Chart 3: Municipal Compensation Requirements



Urban Forest Strategic Plan Implications

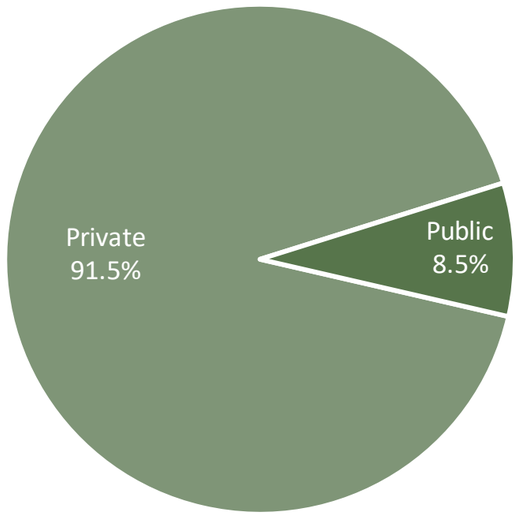
All Forestry contracted services (planting, pruning, removals, and pesticide applications) are included within the definition of landscaping service provider. It is still unknown whether the new living wage will significantly impact Boulder Forestry contracted tree care operations.

Boulder's Urban Forest Resource

Understanding the structure, composition, and condition of an urban forest resource is essential to developing effective management strategies.

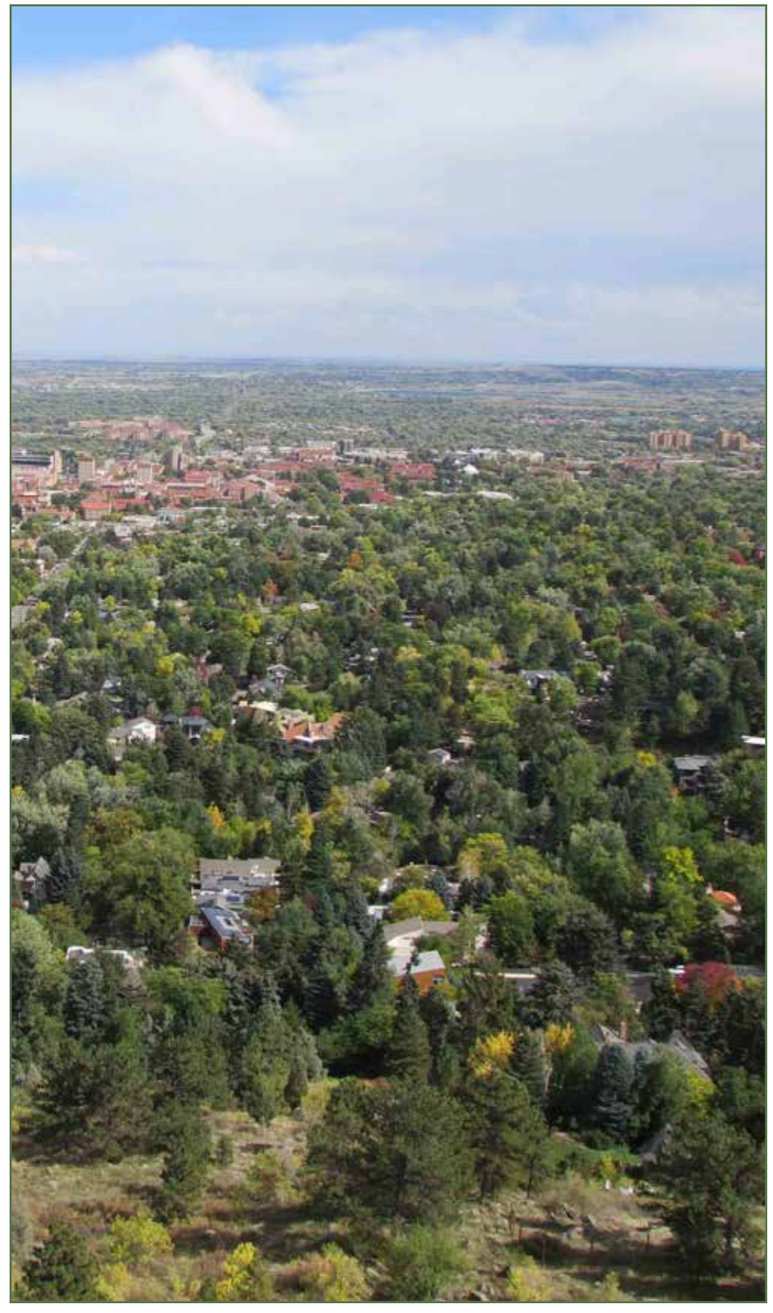
The following information provides an overview of Boulder's urban forest and the public tree resource, including important benchmarks for measuring the success of the UFSP over time. The public tree resource is comprised of all public trees, while the urban forest contains all public and private trees (Chart 4). Boulder's urban forest has approximately 50,800 public trees and 600,000 private trees.

Chart 4: Public vs Private Trees



"We often notice trees as stationary plants that only move with the help of wind, rain or other natural elements. That helps us know they are alive. Another option is viewing the energy that trees emit. During the early or late hours of the day, relax your eyes as if you were caught up in a carefree daydream; focusing on nothing, but still capable of observing. View the edges of the tree and at times you can see shades of transparent silver against the sky background. Every living thing emits energy. Trees give us innumerable opportunities to be aware and connected."

~Submission to Boulder Tree Stories



Urban Tree Canopy

The amount and distribution of leaf surface area are the driving forces behind the ability of the urban forest to produce benefits for the community (Clark et al, 1997). As canopy cover increases, so do the environmental services and socio-economic benefits.

Tree canopy is the layer of leaves, branches, and stems of trees and other woody plants that cover the ground when viewed from above. Understanding the location and extent of tree canopy is critical to developing and implementing sound management strategies that will promote the smart growth and resiliency of Boulder's urban forest and the invaluable services it provides.

In 2015, through a partnership with Trimble and Digital Globe, Boulder used remote sensing and high-resolution aerial imagery (NAIP, 2013) to develop an initial GIS land cover data layer that identifies tree canopy, impervious surface, pervious surface, and water. In 2016, Davey Resource Group completed mapping in some areas not covered in the initial study and provided an accuracy assessment and quality assurance for the overall dataset.

The result is a GIS map layer detailing the location and extent of existing tree canopy and other land cover across Boulder. The analysis does not distinguish between trees on public and private property since the benefits of trees extend beyond property lines. The information can be used by urban forest managers to explore tree canopy in conjunction with other available metrics, including geography, land use, and community demographics. This information also establishes a baseline for assessing future change.

Land Cover

Boulder encompasses 17,473 acres. Tree canopy covers approximately 2,773 acres for an average canopy cover of 16 percent (Chart 1, Table 1). Impervious surfaces such as pavement (roads, sidewalks, driveways and parking lots) and developed area, cover 5,724 acres (33%). The most prevalent land cover is pervious surfaces like turf, low-lying vegetation, and bare soils, covering 8,198 acres (47%) (Map 1). Although all grass, low-lying vegetation, and bare soil cover types are potential planting locations, realistically, not all areas are suitable planting sites due to intended site uses. Examples of sites with limited canopy potential include Golf courses, cemeteries, and sports fields. With these considerations in mind, Boulder has a potential canopy cover of 41 percent.

Tree Canopy by Maintenance District

Land cover was further stratified across 14 tree maintenance districts (Map 3). Boulder's land cover by maintenance district varies, from 30 percent in University Hill to 3 percent in Gunbarrel. Boulder's parks and trail areas include 122 acres of tree canopy, an average of 7.7 percent. Parts of Boulder Creek Path have 70 percent tree canopy cover while natural areas near Boulder Reservoir, Bill Bower Park, and North Palo Park have less than 2 percent.

Chart 1: Land Cover

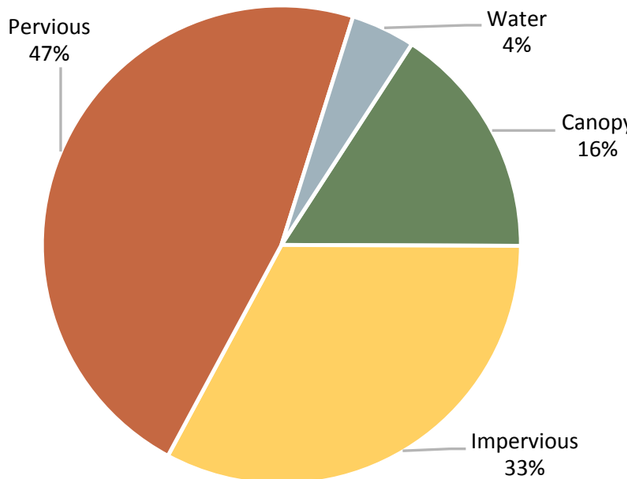
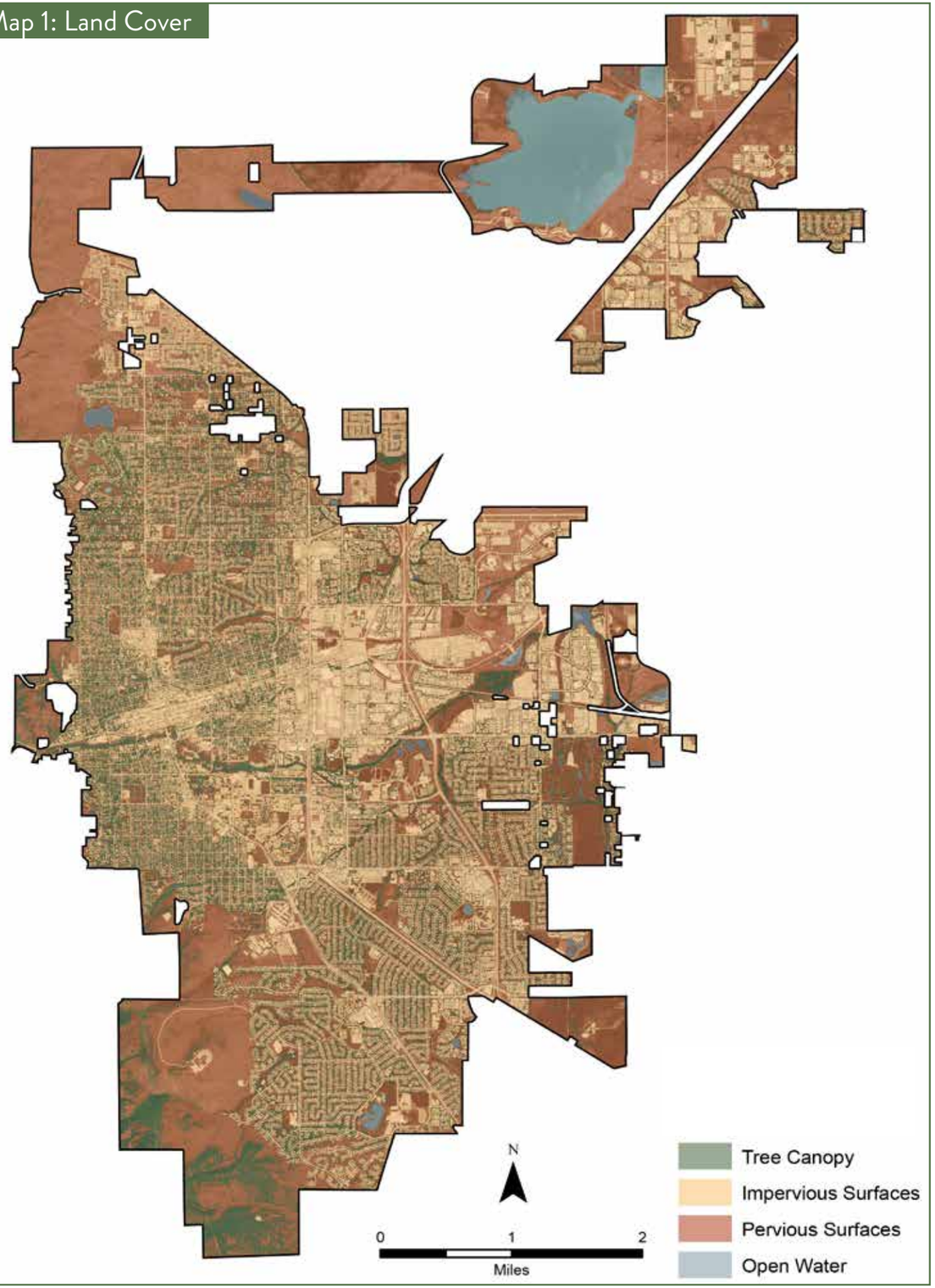


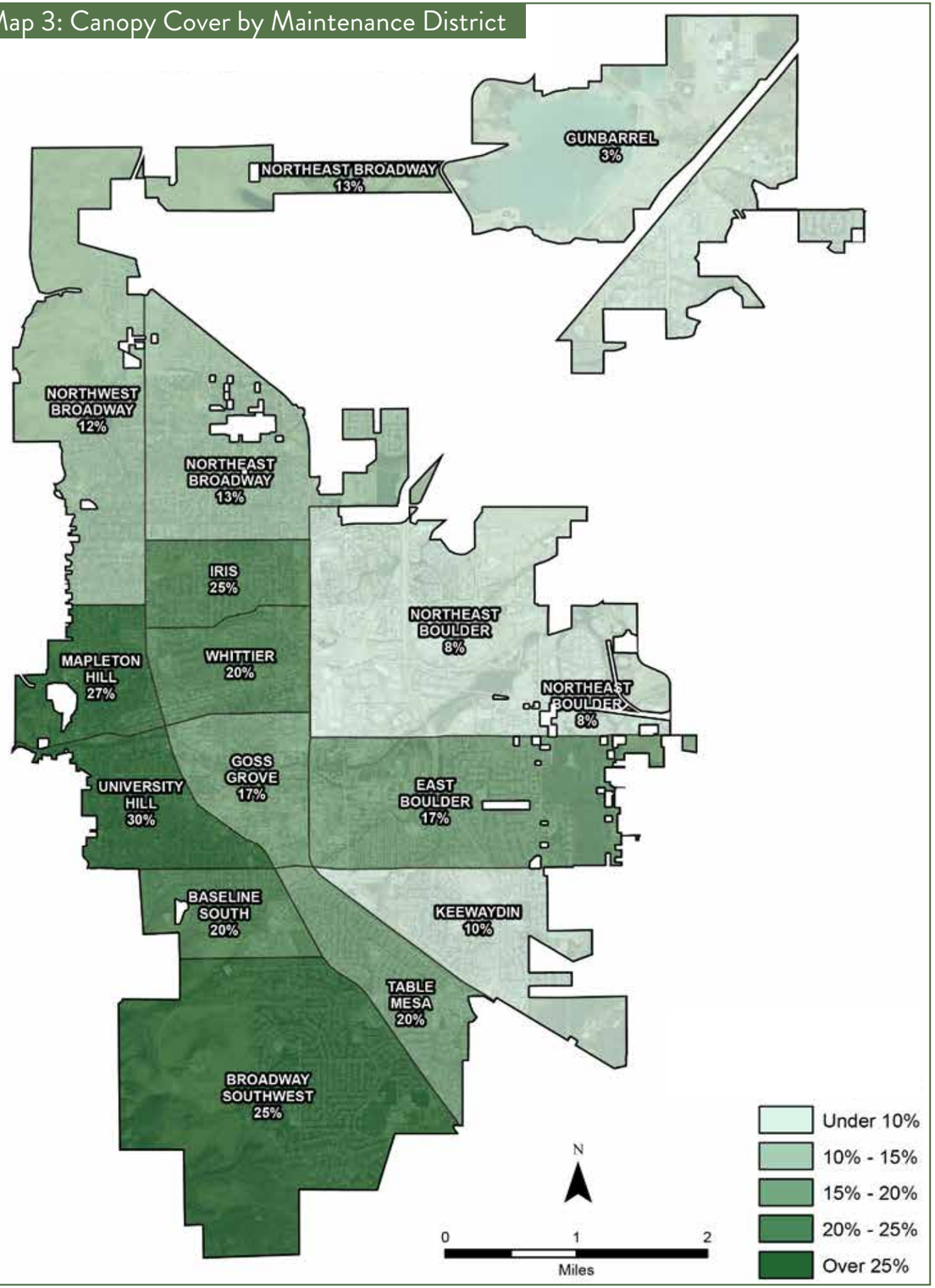
Table 1: Land Cover Classes

Land Cover Class	Acres	Percent
Canopy	2,773	16%
Impervious	5,724	33%
Pervious	8,198	47%
Water	755	4%
Total	17,450	100%

Map 1: Land Cover



Map 3: Canopy Cover by Maintenance District



Environmental Services

i-Tree Canopy (v6.1) was used to calculate the environmental services provided by the entire Boulder tree canopy. This includes annual services to air quality, human health, stormwater runoff, and carbon sequestration. It does not include other tree services such as energy savings or increased property values.

Each year, Boulder's urban forest provides a total of $876,155 in environmental services. The majority of this value comes from reduced greenhouse gases; annually trees sequester 18,709 tons of carbon valued at $676,508. The i-Tree Canopy v6.1 model was used to quantify the value of ecosystem services for carbon storage and sequestration.

The i-Tree Canopy v6.1 model was also used to estimate air pollutant removal rates and monetary values for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM) (Hirabayashi, 2014). Annually, trees in Boulder trap or absorb 139 tons of air pollutants valued at $22,631. Improvements to air quality are also linked to human health services.

The i-Tree Hydro v5.0 model was used to quantify the value of ecosystem services for stormwater runoff. Through model simulation, it was determined that tree canopy reduces stormwater runoff volume in Boulder by more than 15 million gallons per year using precipitation data from 2005-2012. This is approximately 5,408 gallons per acre of tree canopy. Based on an estimated stormwater treatment cost of $0.0118 per gallon, tree canopy contributes $177,016 annually to stormwater services.

Cumulative Stored Carbon

As trees grow, they remove atmospheric carbon to fuel the growth of woody and foliar biomass. Over their entire life to date (lifetime value), the trees in Boulder's urban forest are storing 471,714 tons of carbon, valued at over $17 million (Table 4). In the coming years, as trees are lost to EAB, carbon storage may fluctuate or decrease, depending upon the final disposal or reuse of woody biomass.

Table 4: Ecosystem Services From Tree Canopy

Annual Services		
Air Quality	**Pounds**	**Value ($)**
O_3	183,760	$12,861
PM_{10}	61,560	$9,337
NO_2	18,460	$247
CO	3,380	$143
SO_2	11,620	$43
Carbon	**Tons**	
Sequestration	18,709	$676,508
Stormwater	**Gallons**	
Avoided Runoff	15,001,357	$177,016
Annual Total		**$876,155**
Lifetime Carbon Storage		
Carbon	**Tons**	**Value ($)**
Storage	471,714	$17,056,868

Forest Fragmentation

Forest fragmentation is the result of roads and other urban development creating separations, holes, or pockets that reduce large contiguous forested areas into smaller stands. Fragmentation results in tree canopies that are isolated from each other, reducing habitat value and isolating wildlife populations. Mapping fragmentation can help identify areas where tree planting and new canopy can increase linkages and habitat corridors. The fragmentation study identified 2,289 acres of patch canopy (small isolated patches), 370 acres of perforated canopy (edges and linear sections), and 110 acres of core canopy (Map 4, Figure 3). Fragmentation was a consideration of the priority planting analysis for Boulder.

The effects of fragmentation are well documented in all forested regions on earth. In general, by reducing forest health and degrading habitat, fragmentation leads to loss of biodiversity, increases in invasive plants, pests, and pathogens, and reduces water quality. These wide-ranging effects all stem from two basic problems: (1) fragmentation increases isolation between forest communities and (2) it increases so-called edge effects (Bennett, 2003).

When a forest becomes isolated, the movement of plants and animals is inhibited. This restricts breeding and genetic diversity, which results in long-term population decline. Fragmentation is a threat to natural resilience, and connectivity of forest habitats may be a key component of forest adaptation and response to climate change.

Map 4: Forest Fragmentation

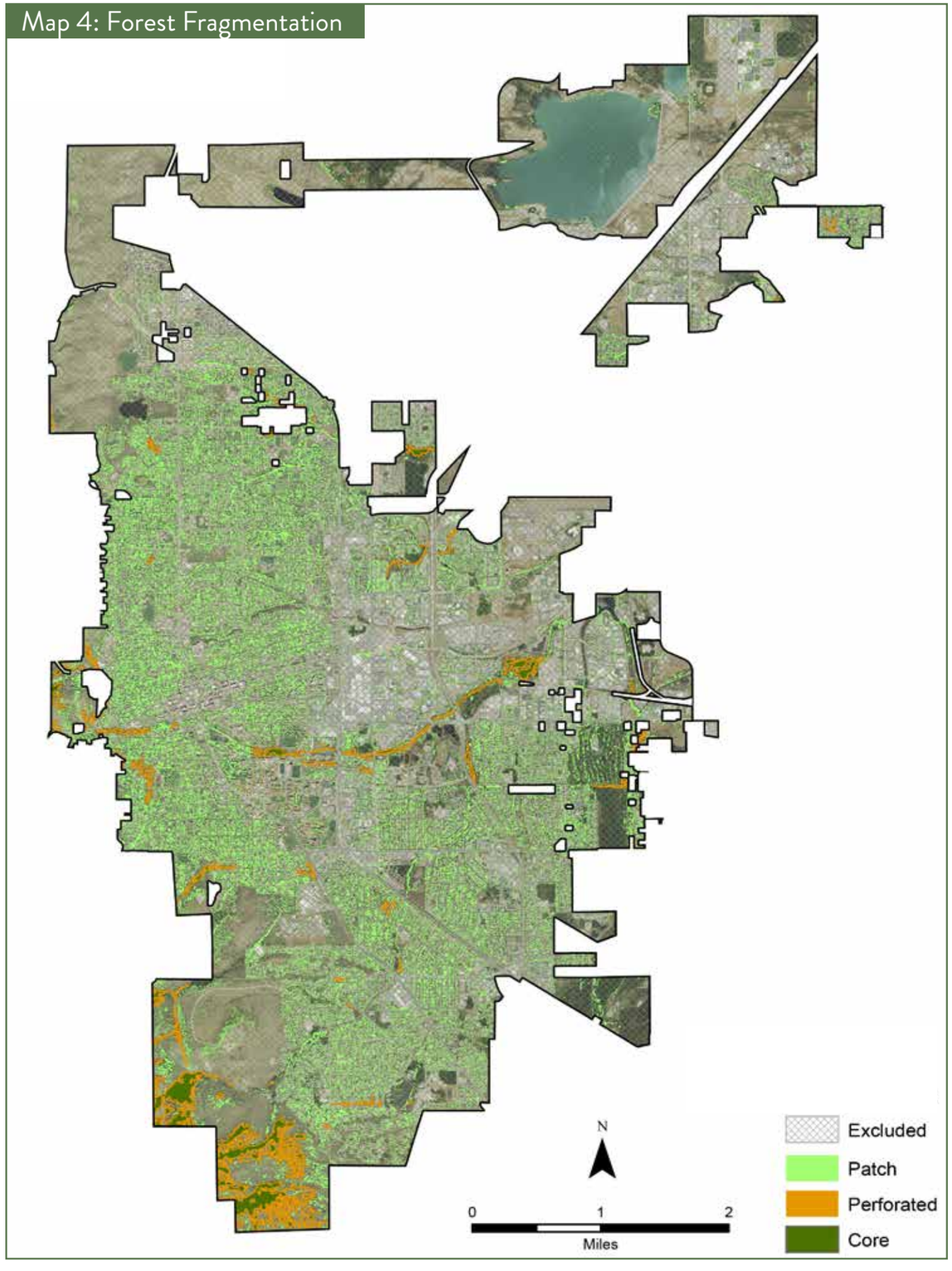


Table 5: Forest Fragmentation

Fragmentation Class	Acres	Percent
Patch	2,289	83%
Perforated	371	13%
Core	111	4%
Total	2,770	100%

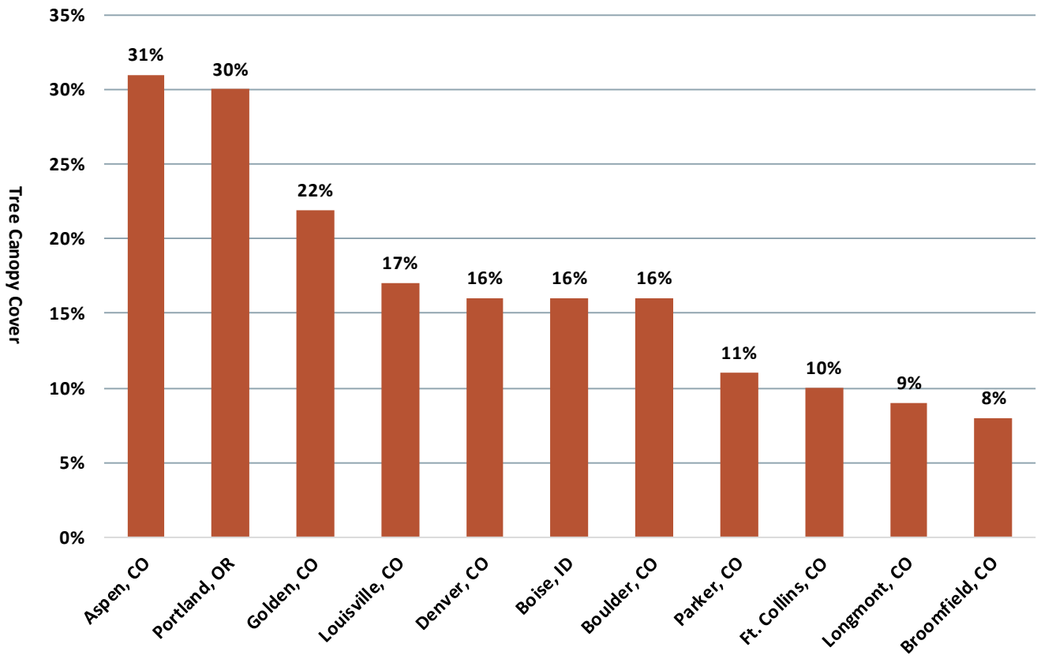
Figure 3: Forest Fragmentation Detail

How does Boulder's tree canopy measure up?

To provide a better regional context for Boulder's urban forest tree canopy, the UFSP provides the Urban Tree Canopy for several comparison communities (Chart 5). Boulder has a 16 percent canopy cover which is approximately equal to Denver and Boise.

It is important to note that different communities may have different canopy cover percents for many reasons, including land use patterns, climate, soil conditions, natural precipitation, and budgets. Every city needs to develop canopy goals that are appropriate for their own community.

Chart 5: Comparison Community Canopy Cover



Management Applications

Understanding the location and extent of tree canopy is key to developing and implementing sound management strategies that promote the sustainability of Boulder's urban forest resource and the services it provides (Figure 4). The data set, combined with existing and emerging urban forestry research, enables managers to strike a balance between urban growth and tree preservation and aids in identifying and assessing urban forestry opportunities. Spatial understanding of the past, present, and future potential for tree canopy is a valuable tool to help managers align urban forestry management with the community's vision for Boulder's urban forest.

Planting Priorities

It could be assumed that all pervious areas, including grass, shrubs, low vegetation, and bare soil (8,198 acres) are potential tree planting locations. Realistically, not all of these areas are suitable planting sites due to intended site uses (e.g., golf courses, cemeteries, sports fields) and because some of these areas are natural areas (without irrigation) that are not appropriate for tree planting.

Potential realistic plantable areas can be determined by excluding those pervious areas unsuitable for planting and including impervious areas where trees could feasibly be added, such as in parking lot islands, along sidewalks, and near road edges.

The Urban Tree Canopy analysis considered site design and environmental factors, including proximity to hardscape, canopy fragmentation, soil permeability, slope, and soil erosion factors to prioritize planting sites on both public and private property for the greatest potential return on investment (Map 5, Figure 4). As young trees mature, they provide more substantial stormwater and environmental services. The analysis identified 4,335 acres of potential planting site in Boulder, where 905 of these acres are high or very high priority planting areas. It is important to note that some of the areas in the planting priority map are not under the jurisdiction of the City of Boulder (Table 6).

Map 5: Priority Planting Sites

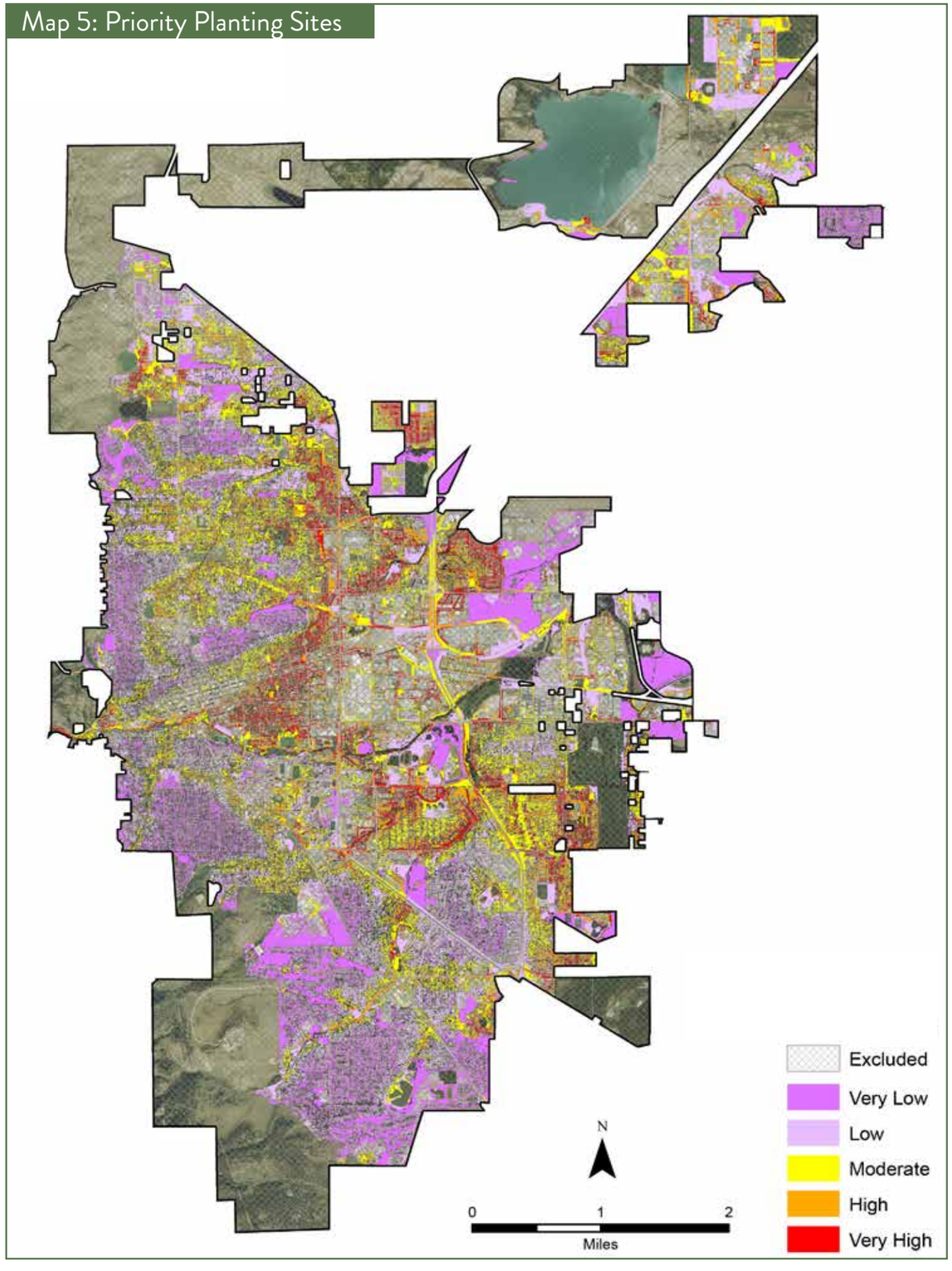
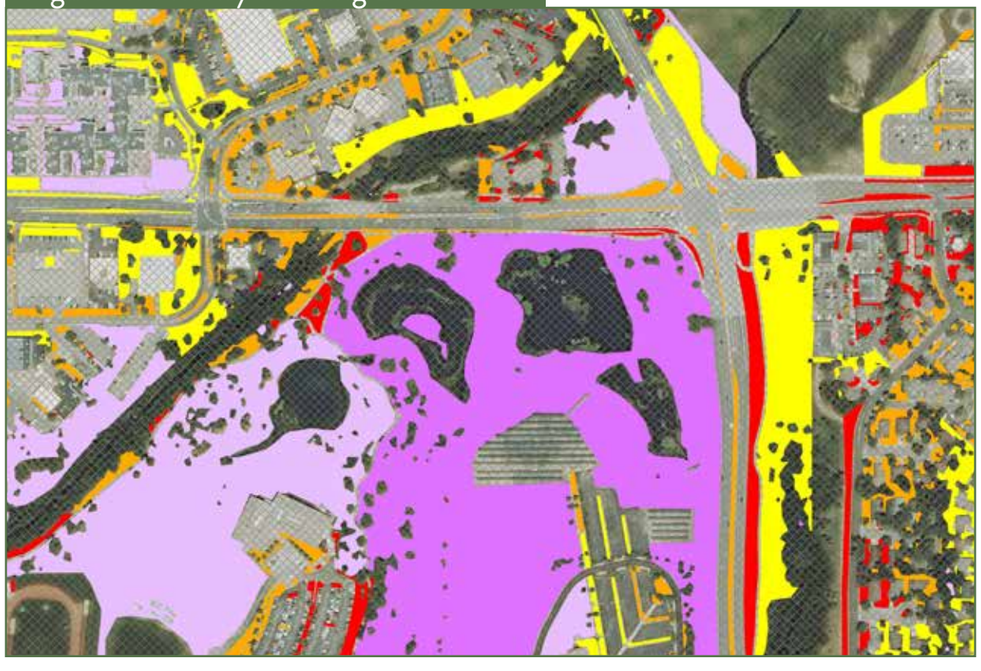


Table 6: Priority Planting Sites

Priority Ranking	Number of Locations	Acres	Percent
Very Low	14,682	1,393	32%
Low	16,906	1,141	26%
Moderate	16,484	889	21%
High	18,449	590	14%
Very High	13,881	314	7%
Total	80,402	4,327	100%

Figure 4: Priority Planting Detail



Public Tree Resource

In 2015, certified arborists collected an inventory of the public trees in Boulder, including details about each tree's species, size, and condition. The inventory recorded the species, size, condition, and geographic location of each tree in an electronic, GIS format.

The tree inventory data was analyzed with i-Tree's Streets, a STRATUM Analysis Tool (Streets v5.1.5; i-Tree v6.0.9), to develop a resource analysis and report of the existing condition of this urban forest.

Boulder's public tree resource includes approximately 50,800 inventoried street and park trees. To replace these trees with trees of similar size, species, and condition would cost nearly $110 million. (Table 7).

Species Diversity

The public tree inventory includes more than 235 unique tree species. This greatly exceeds the mean of 53 species reported by McPherson and Rowntree (1989) in their nationwide survey of street tree populations in 22 U.S. cities. This level of diversity is not typical of a temperate, semi-arid climate. One contributing factor

Table 7: Replacement Value of Top 5 Species

Species	Total	% of Total
Green ash	$12,979,158	11.8%
Siberian elm	$11,505,266	10.5%
Honeylocust	$9,143,368	8.3%
Silver maple	$8,927,310	8.1%
Cottonwood	$6,539,223	5.9%
All Other Trees	$60,860,845	55.4%
Total	$109,955,170	100%

Street Trees

Species	% of Street Trees
Siberian elm	11.3
Green ash	10.9
Honeylocust	8.4
Crabapple	6.1
Silver maple	4.3
Blue spruce	3.5
Austrian pine	2.7
Northern hackberry	2.4
Norway maple	2.4
American basswood	2.3
Russian olive	2.1
Pinyon pine	2.0
Swamp white oak	1.9
Callery pear	1.9
White ash	1.8
Quaking aspen	1.7
Littleleaf linden	1.6
Western catalpa	1.6
Juniper	1.5
Boxelder	1.4
Cottonwood	1.4
Ponderosa pine	1.3
Sugar maple	1.3
Cherry	1.2
Red maple	1.2
Northern red oak	1.2
Bur oak	1.0
All Other Street Trees	19.6
Total	100%

Park Trees

Species	% Of Park Trees
Green ash	9.1
Cottonwood	8.1
Austrian pine	6.2
Plains cottonwood	5.2
Blue spruce	4.6
Ponderosa pine	4.4
Crabapple	3.8
Honeylocust	3.8
Siberian elm	3.7
Willow	3.3
Pinyon pine	2.2
Crack willow	2.1
Northern hackberry	2.1
Boxelder	2.0
Rocky mountain juniper	1.9
Western catalpa	1.8
Bur oak	1.6
American basswood	1.6
Swamp white oak	1.3
Kentucky coffeetree	1.3
White fir	1.2
English oak	1.0
All Other Park Trees	27.7
Total	100%

All Public Trees

Species	% of Public Trees
Green ash	10.4
Siberian elm	9.3
Honeylocust	7.2
Crabapple	5.5
Blue spruce	3.8
Austrian pine	3.6
Silver maple	3.4
Cottonwood	3.1
Northern hackberry	2.3
Ponderosa pine	2.1
American linden	2.1
Pinyon pine	2.1
Norway maple	2.0
Swamp white oak	1.7
Russian olive	1.7
Plains cottonwood	1.6
Western catalpa	1.6
Callery pear	1.6
Boxelder	1.5
White ash	1.5
Littleleaf linden	1.4
Juniper	1.3
Quaking aspen	1.3
Willow	1.2
Bur oak	1.2
Northern red oak	1.1
Rocky mountain juniper	1.0
Sugar maple	1.0
All Other Trees	22.4
Total	100%

is the acidity of Boulder's soils, which makes them more productive than soils in other Front Range cities, allowing a wider diversity of species to be planted. The most predominant tree species are green ash, Siberian elm, honeylocust, crabapple, and blue spruce.

The prevalence of green ash exceeds the general rule that no single species should represent more than 10 percent of the population (Clark et al. 1997). In light of EAB and other significant pests and diseases, many cities are now opting to increase diversity to improve resilience. The 10-20-30 is a widely used standard for urban forestry, which states that urban tree populations should consist of no more than 10 percent of any one species, 20 percent of any one genus, and 30 percent of any one family. The rule encourages greater genetic diversity, and thus, greater resilience. Only 25 of the more than 235 species in Boulder's public tree population represent more than 1 percent of the overall population. Boulder is experimenting with a lot of tree species to increase diversity and overall forest resiliency.

Additionally, at the neighborhood level, some areas are heavily dominated by only a few species. In Northeast Boulder, nearly three in ten trees are green ash. In Mapleton Hill, one-quarter of the trees are silver maples and in Northeast Broadway, one-quarter are Siberian elms. One in five trees among Boulder's parks are cottonwoods.

The lack of species diversity at this level is of concern due to the impact that drought, disease, pests, or other stressors can have on an ecosystem; the urban forest is no different in this respect. Green ash, for example, is already particularly vulnerable to EAB. Silver maples may be at risk as well. While not yet detected in Colorado, the Asian long-horned beetle (*Anoplophora glabripennis*) feeds on maples and other species, including poplars, elms, and willows. A catastrophic loss of one or more of these dominant species would leave large structural gaps in Boulder's neighborhoods.

Future planting should focus on increasing diversity and reducing reliance on overused species. As at-risk tree species are removed and replaced, new species should be introduced when possible. New species should be resistant to the pest issues that currently pose a threat to the region. For example, it would not be beneficial to replace the green ash trees in Northeast Boulder with autumn purple ash, because they would still be at risk from EAB. Ideally, replacement of at-risk species should include a diversity of tree species.

Age Distribution

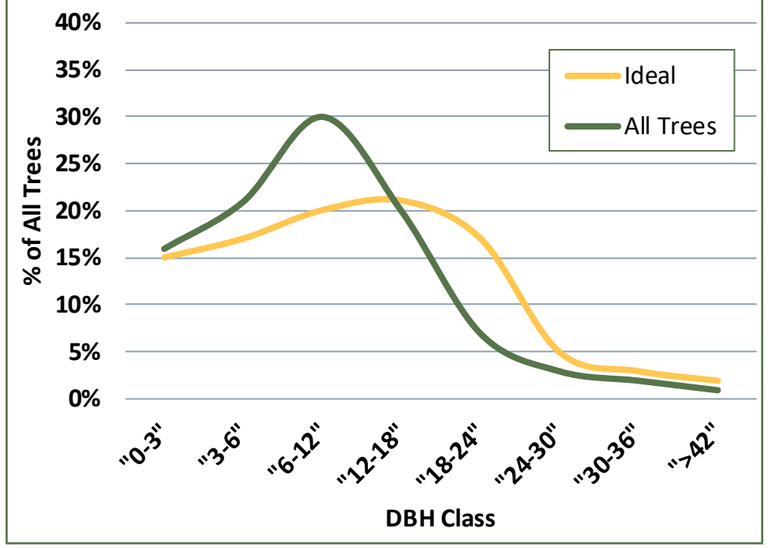
The age distribution of the urban forest is a key indicator and driver, of maintenance needs. The age distribution of Boulder's public tree population is mainly small-diameter trees, with over two-thirds of the trees under 12" Diameter at Breast Height (DBH). Almost 30 percent of the trees are between 6"-12" (Chart 6).

13,034 of young trees (<6" DBH) are medium and large-stature trees that still have a lot of growing to do before they reach maturity. Training, defined as the selective pruning of small branches to influence the future shape and structure of a young tree, is critical at this stage to prevent costly structural issues and branch failures as these young trees mature into their final size in the landscape.

14,911 of the population consists of intermediate age trees with a DBH between seven and twelve inches. Of these, 11,817 are medium and large-maturing trees that will also benefit from pruning to influence their developing structure. 11,817 of the overall population is comprised of small-maturing trees that generally don't exceed 25 to 30 feet in height.

A high proportion of young, large, and medium-maturing trees is a positive indication for the benefits provided by the urban forest, since large shade trees typically provide more shade, pollutant uptake, carbon sequestration, and rainfall interception than small trees. 3,661 of the tree inventory is comprised of mature and over-mature trees with a DBH exceeding 24 inches. When trees approach or reach the end of their natural lifespan, they often have higher maintenance needs and eventually need to be removed to reduce risk and liability.

Chart 6: Age Distribution of Public Trees



Services Provided by the Urban Forest

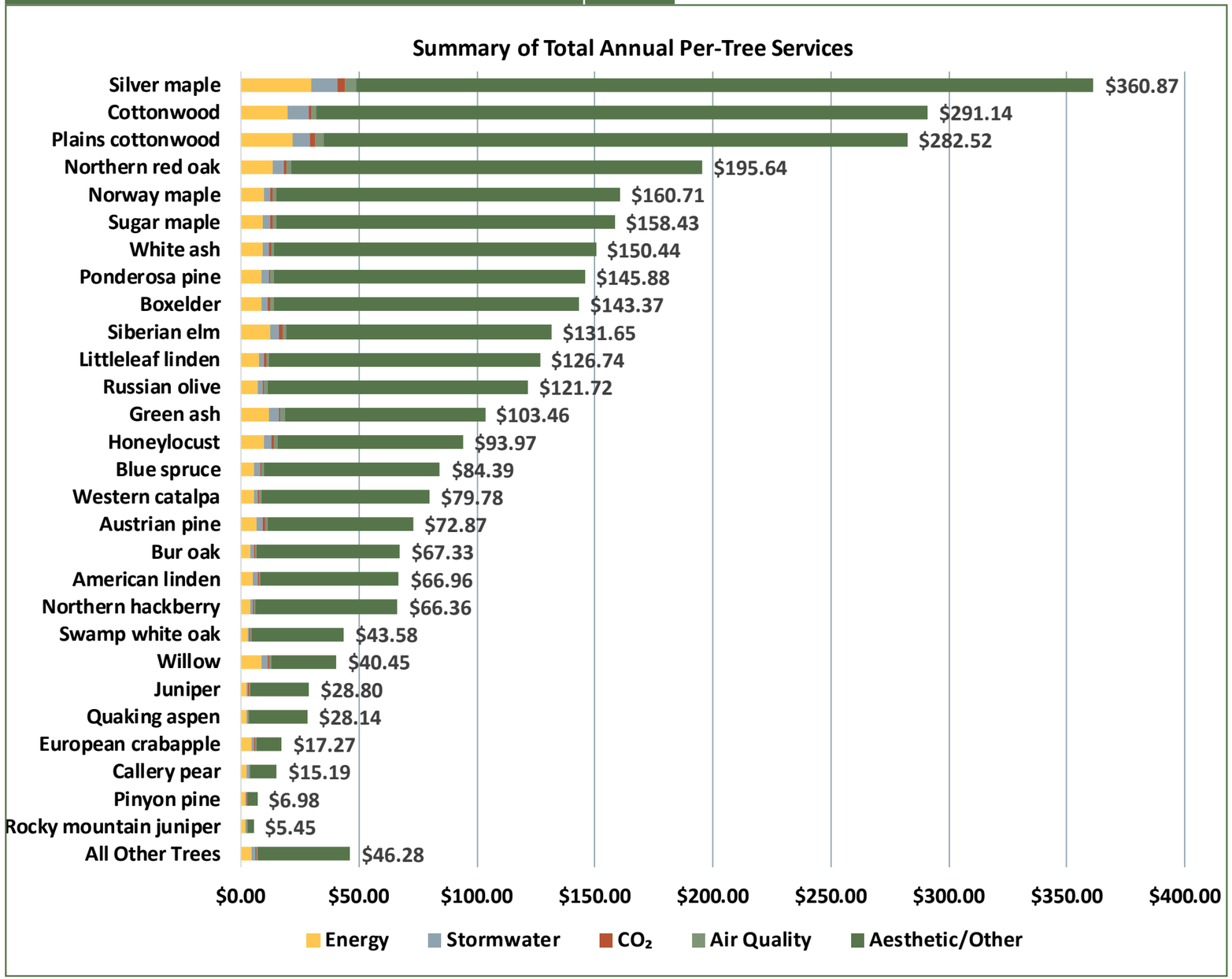
Boulder's public trees provide an estimated 651 acres of tree canopy, approximately 23.5 percent of the overall tree canopy cover. To date, public trees have sequestered 36,892 tons of carbon dioxide (CO_2), valued at $243,490.

Annually, Boulder's public trees provide cumulative services to the public at an average benefit of $102 per tree, for a total value of nearly $5.2 million each year (Chart 7). These annual services include:

- $442,432 in energy use reduction (electricity and natural gas) through shading and climate effects; an average of $8.72 per tree;
- 2,254 tons of CO2 sequestered for an overall value of $43,084; an average of $0.85 per tree.
- $66,282 in air quality improvements; an average of $1.31 per tree;
- 30.6 million gallons of stormwater intercepted for a total value of $153,038; an average of $3.02 per tree; and
- $4.5 million in increased property values and other socio-economic benefits; an average of $88.59 per tree.

It is important to note that three of these top fifteen performing tree species are vulnerable to either the EAB (white ash and green ash) or drippy blight (red oak).

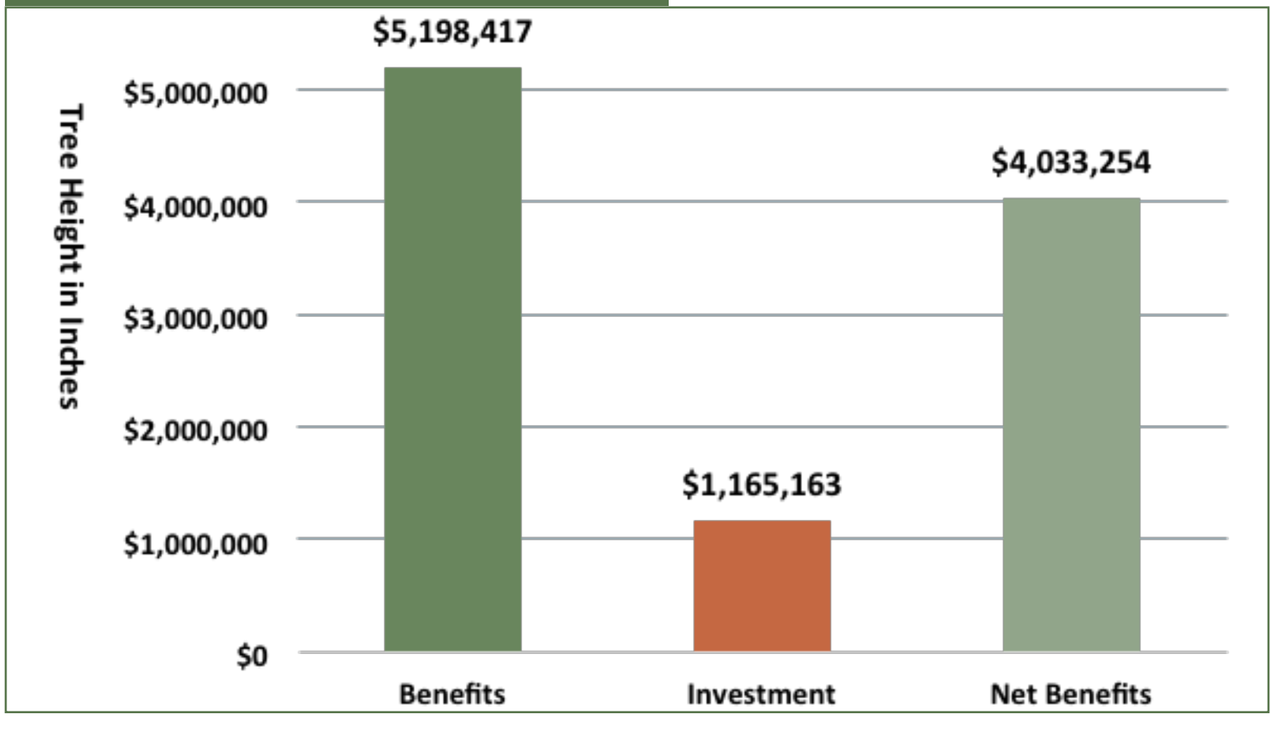
Chart 7: Annual Services From Prevalent Public Tree Species



Return on Investment

When the annual investment of nearly $1.17 million for the management of the public urban forest is considered, the annual net benefit (services minus investment) for the community is over $4 million, an average of $39 per tree (Chart 8). In other words, **for every $1 invested in public trees, the community receives $4.46 in services.** Boulder's benefit-investment ratio of $4.46 exceeds those reported in 2005 for Bismarck, ND ($3 .09), Glendale, AZ ($2.41), Fort Collins ($2.18), Cheyenne, WY ($2.09), and Berkeley, CA ($1.37) (McPherson et al. 2005).

Chart 8: Return on Investment for Public Trees

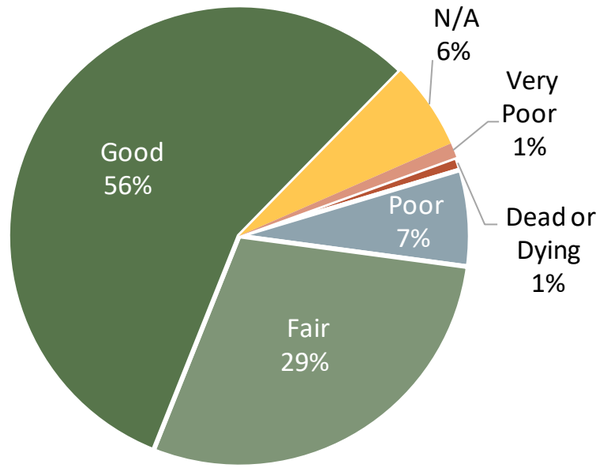


Condition

The majority of trees (91%) in Boulder's public urban forest are in fair or better condition. Less than 7 percent of trees are in poor condition and 1.9 percent are dead or in very poor condition (Chart 9).

While there are some older, mature trees that require structural maintenance or removal, Boulder is fortunate to have a relatively young and healthy public tree population. Proactive management, especially timely training and structural pruning, remains critical to maintain the condition of this valuable forest resource.

Chart 9: Overall Condition of Public Trees



Trees in Open Space and Mountain Parks

The urban forest as discussed in this Plan does not include trees in open spaces and mountain parks. Boulder's Open Space and Mountain Parks (OSMP) include over 45,000 acres of land that have been preserved and protected. Wildlife habitat, unique geologic features, greenways, and 151 miles of trails are all part of OSMP. The open space lands teem with native plants and wildlife and are home to threatened and endangered species. In addition, these lands serve as a buffer between Boulder and nearby development, and contain a tree population that also provides environmental services. A full explanation of how OSMP trees are managed can be found in the OSMPs Forest Ecosystem Management Plan.

City Forestry Programs and Operations

"Boulder Forestry is committed to maintaining a healthy and safe urban forest and to preserving an extensive and diverse tree resource for future generations."

Boulder Forestry staff and programs are nationally recognized within the industry for their expertise and proactive approach to urban forest management. The Boulder Forestry Division currently has seven full-time positions, including: the city forester, a forestry field operations supervisor, three assistant foresters, and two forestry field technicians.

Two to three seasonal staff positions are available to provide support on an as-needed basis. Forestry staff has many years of experience managing Boulder's public trees. The forestry staff also includes International Society of Arboriculture certified arborists and Certified Tree Risk Assessors. These certified professionals participate in training and industry events to keep their skillset and knowledge informed by contemporary industry BMPs.

All individuals from tree care companies performing work to public trees must be city licensed certified arborists and adhere to all applicable industry standards, including ANSI, A300, and Z133. ISA certified arborist contractors follow industry standards, including ANSI, A300, and Z133, and maintain a license to perform tree care to public trees.

Boulder is an industry leader in urban forestry and several programs have been nationally recognized for excellence. The following programs illustrate Boulder's commitment to high-quality tree management.

Core Programs:

- Rotational and safety pruning;
- Tree safety inspection program (TSIP);
- Tree removal;
- Tree planting and replacement;
- Integrated pest management:
  - Protecting pollinators
  - Emerald Ash Borer (EAB) mitigation
  - EAB control methods in Boulder;
- Commercial tree program;
- Tree inventory and asset management;
- Development review, tree protection, and mitigation;
- Enforcement of tree regulations;
- Arborist licensing and staff training;
- Emergency storm response;
- Communication, public outreach and notification;
- Public service requests; and
- Wood utilization.

Boulder's Forestry is committed to maintaining a healthy and safe urban forest and to preserving an extensive and diverse tree resource for future generations.

Rotational and Safety Pruning

Pruning serves to maintain the health, safety, structure, and aesthetic value of individual trees and is needed on a periodic basis as trees grow and increase in diameter and canopy. Maintenance pruning for public trees falls into two main categories: rotational (routine) pruning and safety (risk management), although risk reduction is also a goal of routine pruning. In instances where trees are near busy streets, playgrounds, multi-use paths, and pedestrian areas, pruning can significantly reduce the risk of tree failure. Pruning is also required to ensure visibility in the "sight triangle" at street intersections as well as for traffic signals and signs.

Tree longevity and stability are enhanced with structural pruning from a young age. Structural pruning can also reduce the cost of maintenance over time by reducing the number and size of branches that require removal on mature trees and the amount and size of tree debris. Industry best practices recommend rotational pruning every five to seven years for all public park and street ROW trees.

Until 2012, public street trees greater than ten inches in diameter received maintenance pruning on a ten-year cycle and park trees on an eight-year cycle. In recent years, due to budget constraints, reallocations to manage EAB and storm damage, and increased contractor pricing, the pruning rotation has fallen behind schedule. The current rotation is closer to 14-15 years for street trees > 10" diameter and nine to ten years for all park trees.

Safety pruning outside the rotation is performed on an as-needed basis. Trees are identified for safety

mitigation through routine inspections and maintenance, risk assessment surveys for the Tree Safety Inspection Program, and resident service requests. Urgent hazards are addressed as quickly as possible.

When funding is available, it is generally dedicated to resolve issues in the largest, most mature trees, while younger trees that would benefit greatly from structural pruning and correction become neglected. This deferred maintenance will eventually result in higher, long-term costs that will negatively affect the health and longevity of the overall urban forest, as well as increase future risk of partial or full tree failure.

Adjacent property owners may contract the pruning of public street ROW trees outside of the pruning cycle (B.R.C. 6-6-5 Spraying and Pruning). Property owners must receive prior authorization from Boulder Forestry and hire a City of Boulder licensed certified arborist.

PHS PENNSYLVANIA HORTICULTURAL SOCIETY

Case Study: Pennsylvania Horticultural Society Tree Tenders

PHS Tree Tenders, established in 1993, is one of the oldest, most respected volunteer urban tree planting and stewardship programs in the nation. Tree Tenders was developed as a decentralized program to "train the trainers" about trees, community organizing, communicating with elected officials, working with the media, and neighborhood involvement. The program offers hands-on tree care training, covering biology, identification, planting and proper care. Since inception, the training program has graduated more than 4,000 Tree Tenders in the Greater Philadelphia area. Working in neighborhood groups, the program's volunteers are responsible for planting more than 2,000 trees annually.

Tree Tenders basic training is a one-day or three-evening comprehensive introduction to tree care concepts, offered for a $25 fee with scholarships available based on economic need. The program initially was free, but there were a large number of no-shows, and the participant investment of $25 greatly improved attendance. The scholarship is a way to make sure no one is turned away due to economic circumstance.

Advanced tree tender trainings are available as online webinars which feature a webinar from a nationally recognized tree expert and a quiz. These help provide detail and depth to compliment the tree tenders basic program as well as connect tree tenders with other organizations that can support their projects. Participants who complete all eight 1.5-2 hour webinars receive an Advanced Tree Tenders Certificate.

The program is interconnected to multiple PHS programs, so it is not possible to determine exact program costs. The funding comes from the nonprofit's annual flower show, a state Department of Conservation and natural resources grant, individual donors, and members.

Some of the speakers, including professors from the local university, volunteer their time, reducing potential program costs.

Key Concepts:

- Provide opportunities for volunteers to take on leadership roles;
- Build a team of engaged advocates that understand the community's unique urban forestry challenges and opportunities;
- Scholarships are available; and
- Advanced classes are provided by webinar.

Tree Safety Inspection Program

The Tree Safety Inspection Program (TSIP) is an ongoing inspection and monitoring program for public trees with known structural defects. TSIP aids in the prioritization of maintenance activities to reduce risk, including mitigation pruning and tree removal. Surveys are conducted for public trees on streets, in parks, and along Boulder Creek Path and other greenways. Each tree is inspected once every three to seven years and surveys should be repeated on a maximum seven-year cycle. When a tree's condition exceeds the threshold of safety, the tree is then pruned to mitigate the hazard or removed if risk mitigation is not appropriate. Trees in naturalized areas are only assessed if they have the potential to impact public paths.

A significant focus for TSIP is Boulder's large population of aging silver maples. Many of these trees were planted in the late 1800s and are now over 100 years old. Silver maples are poor at compartmentalizing decay and are weak wooded and prone to limb failure. They represent 52 percent of the trees in TSIP and their future maintenance will strain pruning and removal budgets already taxed by tree removals due to EAB and severe weather events.

TSIP exceeds national standards for tree risk management. As a result, reported claims due to tree failures have been kept to a minimum. Prior to 2006, staff inspected approximately 150 trees per year. Since 2006, that number has increased to an average of 225 trees per year due to the advancing age and size of trees in older neighborhoods. Historical trends suggest the number of removals is expected to increase. All data is collected in the field and stored in a database.

Over time, as high-risk trees have been removed, the overall risk in the public tree resource has been reduced. The scope of the TSIP, however, represents a significant logistical and resource burden on Boulder Forestry operations. The UFSP recommends a review of the program along with an overall risk management policy.

Cavity and decay in public silver maple tree.

Tree Removal

Boulder Forestry is responsible for the removal of public trees that are dead, dying, structurally unsound, or threatening to people or property. Trees that pose a danger of spreading insect or disease pathogens may also be removed to protect the overall urban forest. Trees that are ten inches in diameter or smaller are typically removed by forestry staff, while large tree removals are contracted through local arborists.

Recently, several large contracts have been awarded to out-of-state arborists due to the increasingly prohibitive costs of local arborists. Sourcing only to local companies requires a deliberate call to action from Boulder voters, including a commitment to additional funds.

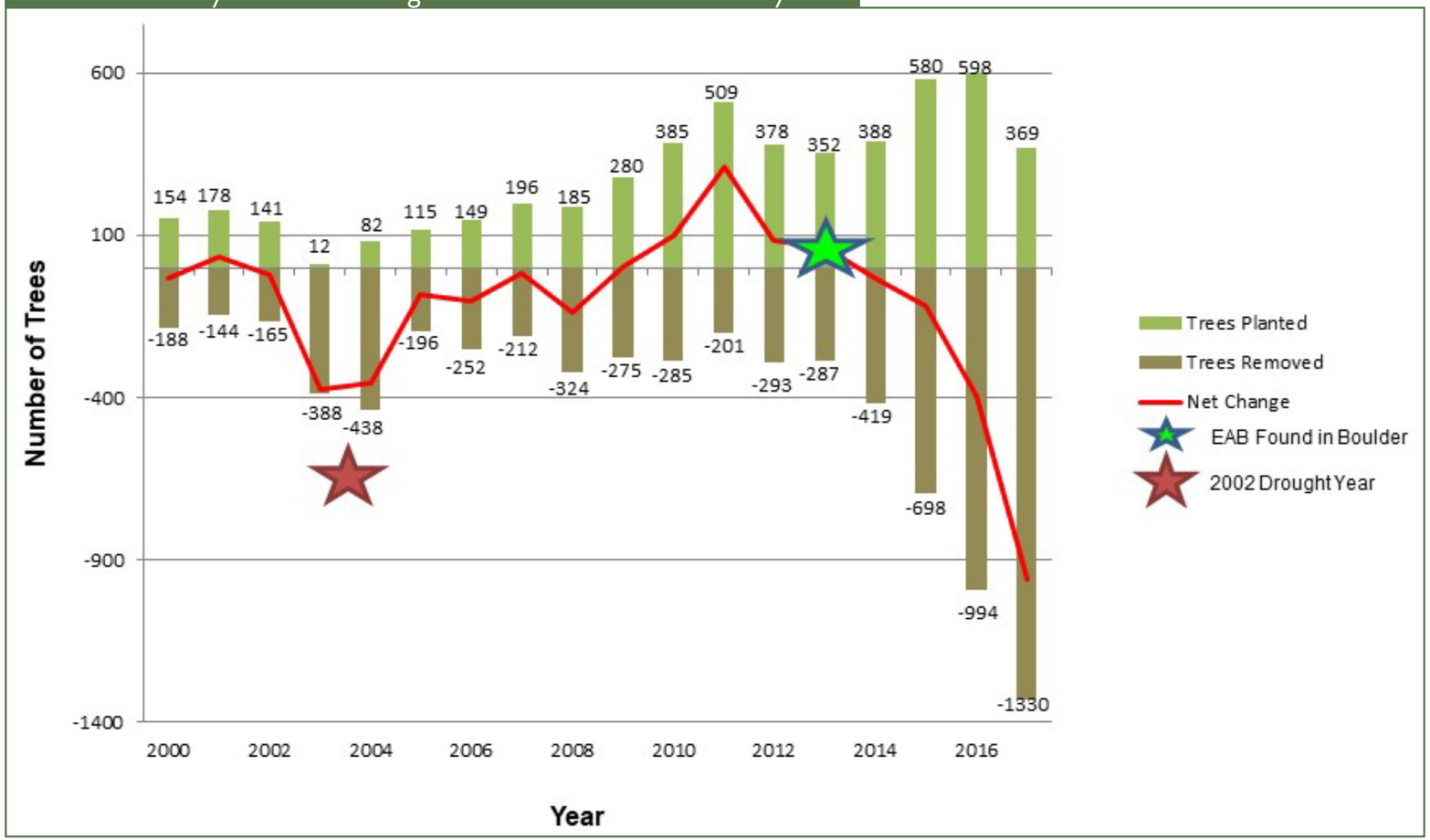
Prior to 2013, Boulder Forestry removed an average of 250 trees per year (Chart 10). Since 2013, removals have increased significantly to over 900 trees in 2016 and 1,300 trees in 2017. Boulder Forestry estimates that these numbers will continue to increase even further as a result of EAB, severe weather events (e.g., the 2014 freeze and 2016 spring snowstorms), and the continued decline of historic silver maples in Mapleton Hill, University Hill, and Whittier maintenance districts. Trees are also removed by other city work groups or private entities because of city construction projects, flood mitigation projects or private development.

Despite an increase in removals, tree removal decisions (whether within the city or private) development process are not taken lightly and trees are preserved whenever possible. For private development projects, tree removal decisions are made based on specific criteria, which can involve the Planning Board or City Council. The project must satisfy and balance criteria for removal and is agreed on by Forestry staff prior to advancing to Planning Board.

Forestry staff serves in an advisory role and as an information resource for determinations on tree removal in development and city construction projects. The decision to remove a public tree through development is ultimately made by the project manager, advisory board, or City Council. Thus, Forestry does not make removal decisions for projects in other departments.

When a private resident wants to remove a public tree, the Forestry and the Planning Department work together to explore alternatives to removal and to determine if the tree is worthy of preservation.

Chart 10: History of Tree Planting & Removal - Boulder Forestry



Tree Planting and Replacement

To maintain the public tree resource and urban tree canopy cover along with the environmental, social, and economic services that the urban forest provides, Boulder Forestry replaces public trees that have been removed and plants additional trees where existing space and infrastructure allow. Tree planting activities are divided between an in-house crew and outside contractors. The amount contracted varies from year to year based on how busy the in-house staff members are with other tree activities, such as storm damage response or service requests. In-house planting is less expensive, so the city could plant more trees annually if in-house was used exclusively for plantings. Trees in commercial locations and for special planting initiatives, such as ash replacement, are generally planted by outside contractors.

To help offset the loss of environmental services caused by the removal of a mature tree, industry standards recommend replacing trees at a minimum of two new trees for every one tree removed (2:1). However, due the high number of recent tree removals along with budget shortfalls, Boulder Forestry has struggled to maintain a 1:1. The 2017 budget allocated $18,500 to planting. To reach the 2:1 goal, future budgets should receive substantial increases.

Historically, Boulder Forestry's Tree Planting Program has planted between 200 to 600 trees each year, depending on funding. Hundreds more are added to the landscape through city projects and private development activities. Maintaining tree diversity is the key to resilience in the face of invasive tree pests and climate change. Boulder Forestry staff strives to plant a minimum of 35 different tree species annually. To maximize tree services, 90 percent of new trees planted by Boulder Forestry are large-maturing species.

Tree establishment requires regular irrigation and special attention to soil quality. Sites with a functional irrigation system receive priority status for replacement trees. Due to existing limitations, Boulder Forestry cannot replace all trees. This is especially true for trees along arterials or adjacent to rental properties, due to lack of irrigation or lack of functional irrigation systems. Irrigation was required at planting but often not maintained for site review projects.

Soils in West Boulder are generally fair to good with acidic pH and higher organic matter content. Some areas in East Boulder and Gunbarrel have low soil organic content, low soil fertility, poor drainage, as well as variable soil type and pH. Boulder Forestry collaborates closely with city Planning and Transportation staff to ensure species selection accounts for multiple site and soil variables for city and private development projects.

Currently, the Tree Planting Program has a Request to Proceed memo signed by the city manager, which allows Boulder Forestry to purchase trees outside of normal purchasing requirements. This strengthens the program considerably since it is vital to select only high quality, neonic-free, diverse tree species. Low-cost is not always the highest priority when selecting quality tree stock.

Living Legacy Program

The Living Legacy Program provides individuals and organizations with the opportunity to honor and commemorate the memory of individuals and special events by planting a tree in Boulder's city parks. While prices vary due to species, size, and time of purchase, the average cost per tree is approximately $275.

UP WITH TREES

Case Study: ReGreen Tulsa

ReGreen Tulsa was a successful public-private partnership to plant 10,000 trees, a prime example of urban forest resiliency in action. A December 2007 ice storm caused unprecedented damage to Tulsa's urban forest. Over 20,000 trees were lost throughout the community, including 7,000 trees in city parks. In response, Tulsa's mayor at the time, Kathy Taylor worked with Up with Trees and leveraged city resources to kick off the project in 2008. Ultimately, through individual and corporate donations the community dedicated $1.5 million in private funding which was matched by the Tulsa Community Foundation to fund the $3 million nine-year project.

A diverse species palette, focusing on storm-resilient trees was selected. Trees were planted at schools, parks, city properties, and in 16 neighborhoods. The project had 15 collaborative partners to plant trees at 196 locations throughout Tulsa. Volunteer crews were trained to help plant the trees, recruiting many residents from nearby neighborhoods. It is estimated that around 5,000 volunteers participated in tree planting events. Up with Trees recruits one volunteer for every 2 trees planted, at events that are typically held 9-11am on weekend mornings. ReGreen plantings became the catalyst for the development of the Citizen Forester program to develop volunteer leadership.

Over the course of the ReGreen program, managers identified several strategies and elements that contributed to program success. First, ReGreen Tulsa had a sense of urgency due to the massive citywide storm damage and this sparked strong political and community support for a tree planting initiative. The program vision and funding came together relatively quickly (in about 2 months) based on existing partnerships with the Tulsa Community Foundation, City of Tulsa and Up With Trees. Because the program was based on a foundation grant and nonprofit donations, the funding was relatively stable, rather than subject to city budget fluctuations.

When planting thousands of trees, even small price reductions in per-tree cost can really add up - in this case, to an estimated $250,000. ReGreen trees had a cost of $300 for planting, watering and warranty. Today, UWT estimates that cost at $400 per tree due to inflation and stock availability. Ultimately, one of the main program successes was a shift in public perception - through education, advocacy, and dialogue with volunteers and community leaders - that changed from trees being perceived as an aesthetically beautiful amenity to a valuable infrastructure asset.

Program organizers acknowledge several lessons learned from this program's implementation. They recommend collaborating with partners (school district, fire department, etc.) earlier, and more carefully considering the locations of trees to increase canopy in areas of highest need. It was challenging to find planting locations in low income, low canopy areas because of the higher prevalence of renters, who lacked the ability to provide maintenance, or simply lacked the time to care for a newly planted tree. To overcome this challenge, UWT plans to work closely with the Working in Neighborhoods Department of the City of Tulsa, and spend more time canvassing and cultivating community support. The tree mortality rate ranged from 3 percent in years of regular precipitation to 9 percent in drought years, which was still below the industry average of 10 percent. By spreading tree planting over 9 years, the risk of catastrophic loss - in the event of severe drought - was mitigated. Perfecting summer irrigation timing and methods was seen as a key to successful tree establishment.

Key Concepts:

- Establish a tree planting goal and a timeframe. Allow the first year to be a planning phase;
- Collaborate with partners early and often;
- Create a call to action and clearly articulate "Why now?";
- Focus tree planting where community need is greatest;
- Work strategically to source high-quality, diverse, low cost nursery stock;
- Diversify funding sources and partners; and
- Celebrate success.

Integrated Pest Management

Boulder's ecologically based Integrated Pest Management (IPM) program is a dynamic, decision-making process that relies on observation and knowledge of the target organism and the ecosystem where it lives. IPM selects, integrates, and implements a combination of strategies to prevent or manage pest populations, including 1) mechanical control, such as pruning or removal of diseased or dead trees, 2) cultural, such as proper irrigation and optimal site choice for tree planting, 3) biological control, such as releasing natural enemies of pests, and 4) chemical or pesticide controls.

Boulder's IPM Program has evolved over the past ten years and is recognized nationally as an exemplary program. In 2011, the US Forest Service recognized Boulder in the National Response Framework for Thousand Cankers Disease (TCD) of Black Walnut. Boulder Forestry staff has been invited to speak at national and regional conferences. Federal agencies and several national industry groups have convened in Boulder to tour emerging pest sites and learn firsthand from the experiences of Boulder's forestry staff.

Boulder Forestry coordinates closely with Boulder's IPM Coordinator. Monitoring activities, early detection, and rapid response efforts of both public and private trees are key components of the IPM Program. Monitoring activities include visual surveys, trapping (with or without pheromones), and destructive sampling at the time of tree removal. Generally, the earlier a pest problem is detected, the more options are available for management. Unfortunately, current staffing levels often limit opportunities for field inspections and follow-ups are infrequent. The backbone of IPM monitoring is the annual Tree Health Survey, a citywide survey of all trees that can provide early detection for potentially life-threatening insect and disease outbreaks. The survey allows staff to detect tree health trends on a block, neighborhood, and citywide scale.

Dr. Whitney Cranshaw and Dr. Ned Tisserat from Colorado State University examining a walnut tree with Thousand cankers disease.

Trees under stress are more prone to attack from insects and disease. Although stress cannot totally be eliminated, there are cultural controls. Boulder Forestry uses these controls to improve the health of public trees and therefore reduce the chance of attack from insect and disease pests. Methods include better species selection during the development review process, increasing tree diversity, proper tree placement, monitoring contractors for proper planting techniques, and mulch rings to promote a healthy growing environment and systematic pruning rotation.

The walnut twig beetle and *Geosmithia* fungus.

Dr. Ned Tisserat leads a Thousand cankers disease training in Boulder.

In Boulder, the primary IPM control is mechanical via tree removal, as it is often the only or best management option for many insect and disease pests, such as Dutch elm disease. Forestry staff has removed or had removed per city ordinance over 1,000 trees since 2005 infected with TCD of walnut, DED, or ips beetle in spruce to prevent spread to other trees.

Boulder's IPM Policy directs that pesticides be reduced or eliminated wherever possible. Most pesticides are banned on city properties, where the majority of Boulder's public properties either have no pesticides applied, or pesticides are minimized and strategically applied as a last resort.

Tree pest management, particularly for exotic pests, can be challenging since trees support a wide range of biodiversity and other species can be affected by pesticide treatments. Management decisions are based on the severity of the pest and its threat to tree health and the urban forest. In cases where pesticide use is required to protect the life of trees, and the overall environmental benefits from preserving trees are estimated to outweigh the impacts to non-target species, pesticide treatment plans are carefully designed to mitigate non-target impacts as much as possible.

Pesticide application guidelines for Forestry include:

- Pesticides are used only as a last resort, when the health of trees is threatened, alternative controls are not available, and/or pesticides are the BMPs for an invasive pest;
- Trunk and soil injections are used whenever possible to reduce pesticide drift and minimize public contact; and
- Only the least toxic available pesticides are used and over time alternatives have been found that further reduce toxicity levels.

Many alternatives utilized by Boulder Forestry are not the industry norm. To continue to identify the least toxic chemical controls and to utilize a variety of control options, Forestry staff must continue collaboration with outside agencies on projects to evaluate controls. The existing ordinance allows property owners to treat adjacent public street trees but only with city authorization. Most frequently, the property owners who treat the adjacent public street trees do not communicate with or get approval from the city. Boulder Forestry and the IPM Program have relied on outreach and education to provide information to the public about the impacts of pest control decisions on public health and the environment. More options, including legal methods, need to be explored and developed to assist the public in complying with the ordinance.

Protecting Pollinators

To protect bees and other pollinators, city staff collaborated with Bee Safe Boulder (now merged with People and Pollinators Action Network) on Council resolution No.1159, 2015, which banned neonicotinoid-active ingredients on city-managed parks, playing fields, ROW, along watersheds and ditches, open space lands, public trees and other areas under city jurisdiction.

It allows for their use on trees if tree health is threatened, but, it requires a formal exemption from the city manager.

Honeybee hives are preserved whenever possible during tree care operations. Beekeepers are contacted to relocate hives, or, if the timing is right, hives are relocated to the Forestry woodlot where they can safely swarm.

The pollinator program provides external resources to become a citizen scientist and help track native bees through the Bees' Needs project at CU. Bumblebee sightings are tracked in the Xerces Society's Project, BumbleBee. The city also launched the Boulder Pollinator Garden Project to work with public, private, and non-profit partners and homeowners to encourage the creation of high-quality pollinator habitat throughout Boulder, both on public and private properties.

The city provides outreach and education about pollinators and other biodiversity issues by hosting Pollinator Appreciation Month each September. Partners, such as CU, local NGOs, and volunteers, offer a variety of events, culminating in the Bee Boulder Family Festival. This festival is attended by hundreds of children who learn about the importance of pollinators through fun and creative activities.

Emerald Ash Borer Mitigation

Ash trees provide considerable economic, environmental, and socio-economic services to community members. Unfortunately, EAB was discovered in the City of Boulder in 2013. Boulder was the first city in Colorado to identify EAB and is at the forefront of the state's management program. Ash is one of the most abundant tree species in urban areas across Colorado, including 12 percent of Boulder city parks and ROW trees by numbers. Boulder's ash trees contribute approximately 25 percent of the overall canopy cover. The estimated number of public, private, and naturalized ash in Boulder is over 70,000 trees at an estimated value of $18 million.

The Forestry Division has six main themes for EAB management in Boulder:

- Protect public safety and minimize liability;
- Maintain a healthy, diverse, and sustainable urban forest;
- Maintain or increase the urban tree canopy to maximize the environmental, social, and economic services provided to Boulder;
- Minimize risks to non-target organisms from pesticide applications;
- Minimize costs; and
- Minimize disruption to other forestry operations.

Emerald Ash Borer (Adult)

A 2015 study session with the City Council garnered unanimous support for Forestry's proposed long-term management strategy. Boulder management components include:

- Planting;
- Removals;
- Pesticide applications;
- Biocontrols;
- Quarantine;
- Outreach and engagement; and
- Wood debris management.

EAB Control Methods in Boulder

After the initial discovery of EAB in Boulder, the USDA Animal and Plant Health Inspection Service (APHIS), the agency responsible for the federal EAB quarantine, declared EAB in Colorado as an "incident" equivalent to a wildfire and instituted an Incident Command System (ICS). The ICS allowed all affected agencies to share communication while developing mitigation and management strategies and outreach materials for EAB in Colorado. The EAB ICS was in place from September 2013 through April 2015, where it transitioned to the Colorado EAB Response Team. Agencies participating in the EAB ICS and the Colorado EAB Response team include: APHIS, Colorado Department of Agriculture (CDA), City of Boulder, Boulder County, University of Colorado (CU), Colorado State Forest Service (CSFS), and Colorado State University (CSU).

To slow the spread of EAB in Colorado, the CDA imposed a quarantine on the movement of all ash tree products and hardwood firewood out of Boulder County.

To assist staff with EAB monitoring and management, Boulder Forestry consulted with two of the leading national EAB researchers and two local experts in entomology and tree pest management: Dr. Deb McCullough, Michigan State University; Dr. Krista Ryall, Canadian Forest Service (CFS); Dr. Whitney Cranshaw, Colorado State University; and Dr. Sky Stephens, U.S. Forest Service. The group provided research documents, guidance on EAB strategies, and information on possible differences in EAB behavior in Colorado.

Since initial detection, over 1,350 public ash trees have been removed from Boulder's urban forest. Additional

ash removals are currently behind schedule when Boulder Forestry had to adjust priorities and focus on the removal of more than 500 dead Siberian elms, which had been killed by a November 2014 freeze event.

Approximately 5,300 public ash trees remain in city parks and ROW. Boulder Forestry is treating approximately 25 percent of the remaining public ash trees through pesticide application in a three-year rotation, where the remainder will be removed over the next several years. To manage this transition, Forestry staff members are proactively removing ash trees that are near ash exhibiting symptoms of EAB, in poor condition, or poorly placed (e.g., under power lines). Ash trees in development projects are also being phased out when possible, including private development and city projects (e.g., Transportation, Parks and Recreation, and University Hill General Improvement District Capital Improvement projects).

Pesticides

Boulder's EAB strategy complies with the city's Integrated Pest Management Policy and takes into account non-target effects, environmental impacts, and long-term objectives. Pesticides must be evaluated prior to use and are only used if other options are not feasible.

Forestry staff assessed four commonly used pesticides utilizing data from the EPA and other regulatory agencies, advice from leading experts in EAB management, and open literature. The decision-making process for EAB treatment is complex due to differences between products, diverse use rates, multiple methods of application, timing of applications, pest control efficacy, and environmental considerations.

Control Method: Application of Pesticide

The analysis of pesticide options indicates that imidacloprid, a neonicotinoid insecticide, posed a high risk to pollinators and other non-target organisms, while showing inconsistent efficacy for EAB control. In March 2014, Forestry and IPM staff recommended that the city manager prohibit the use of imidacloprid for EAB control on city properties, including public street ROW.

Two products are currently being used by Forestry staff for EAB management: TREE-äge and TreeAzin, a "semi-synthetic" tree injection and a natural tree injection. There are knowledge gaps about each of these products, and Forestry staff is seeking partnerships and research opportunities to investigate potential environmental

Control Method: Biocontrol (Parasitic Wasp Eggs)

impacts from TREE-äge. In 2014 and 2015, TREE-äge was applied to public ash trees within the known infested areas in a targeted strategy. This product will continue to be evaluated as more information becomes available. As local EAB populations decline due to mortality in untreated ash trees, it is likely that the number of trees will be reduced each year for both products.

More than 25 percent of Boulder's public ash trees meet the criteria for EAB treatment. All public requests for pesticide applications are being tracked by Forestry staff. Feedback from contractors suggest that many homeowners are treating ash trees, but only a small percent report these activities.

Biocontrols

Four species of non-stinging parasitic wasps have been released in Boulder to combat EAB. Additional releases are planned over the next few years. Two of the species have been found in traps, which is proof that they are successfully reproducing and overwintering in Colorado. The long-term goal for natural enemies is to suppress EAB populations in the post-outbreak phase. If effective, this could result in a reduction in the amount of pesticides applied in the future.

Quarantine

EAB and many other pests are dispersed through multiple pathways, including movement of nursery stock and firewood. Firewood is a raw forest product that is widely utilized and moved throughout the U.S., with relatively limited consideration of the potential for pest dispersal or the associated risks.

To restrict movement of pests, federal and state quarantines prohibit the transport of firewood and other ash wood materials outside of quarantined areas.

Because EAB is a federally quarantined pest, APHIS works with state cooperators to detect, control, and prevent the human spread of EAB. To restrict intrastate movement of regulated articles, including live plants and wood from ash and EAB, the Colorado Department of Agriculture (CDA) has imposed and is enforcing a quarantine on the movement of all ash tree products and hardwood firewood out of Boulder County. After discussions with local trash haulers, CDA also included small portions of Jefferson and Weld Counties to gain access to two landfills within the quarantine area and control flood debris and EAB-infested material. The state quarantine took effect on November 12, 2013 and a federal quarantine was enacted in April of 2014.

CDA enforces the quarantine by entering compliance agreements and inspecting arborists, woodworkers, firewood dealers, and others handling regulated articles. Regulated articles include EAB specimens, ash nursery stock, ash logs, branches and chips, green lumber, all hardwood firewood, or any other article, product, or means of conveyance that may present a risk of spreading EAB. The sale and movement of regulated articles out of a quarantined area are prohibited. Movement of regulated articles, other than nursery stock, is allowed if the regulated material meets certain specifications verified during inspection.

Existing city code, B.R.C. Chapter 6 Protection of Trees and Plants, 6-6-2 Removal of Dead, Diseased or Dangerous Trees allows the city to enforce regulations for dead ash trees located on private property where there is the potential to threaten public property. Forestry staff, Boulder Police Department, and the City Attorney's Office are coordinating to enforce the removal of dead ash trees on an as-needed basis.

Forestry begins enforcement actions with letters, phone calls, and other communication. If there is no compliance, Forestry collaborates with the City Attorney's Office and Boulder Police Department for an administrative warrant to allow a contractor to enter onto private property to remove the tree.

Forestry anticipates that current staffing levels will not be sufficient to support enforcement efforts as EAB reaches its peak.

EAB Outreach and Engagement

Education and outreach are critical components of Boulder's EAB management strategy. Forestry staff has collaborated with other city departments and outside agencies to increase outreach efforts. Boulder Forestry is proud to have developed effective EAB workshops and dissections for private industry and other forestry stakeholders. In 2016, Boulder hosted EAB tours in cooperation with the Colorado EAB Response Team. Participants included foresters and City Council members from nearby communities. The response to this tour was positive and Boulder hosted tours again in July of 2017.

Consistent with long-term department goals, Forestry will continue to implement strategies that "Take Care of What We Have" and proactively engage in "Community Building" as a method to address the sustainability of Boulder's urban tree canopy. Staff will continue to explore additional opportunities to increase awareness, collaborate on community tree plantings, identify environmentally sensitive methods for managing wood debris, and focus efforts to increase investment in tree care and replacement over time.

Public Education / Outreach / Engagement

Education and outreach are critical components of response to an invasive tree pest. Emerging Pests in Colorado (EPIC) and the Colorado EAB Response Team are two inter-agency working groups formed to increase industry and public awareness about invasive pests. Participants included staff from the CDA, CSFS, CSU, APHIS, and foresters from several cities including Boulder, Denver, and Fort Collins.

Multi-agency efforts to raise industry and public awareness about the threat of EAB and other invasive pests since the EAB detection include:

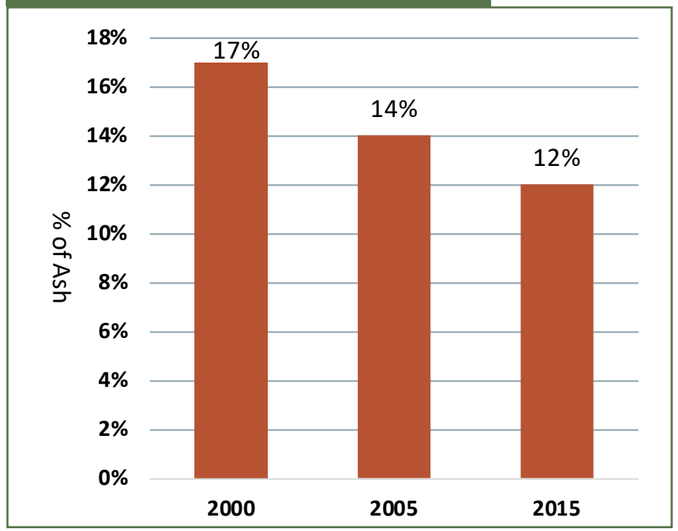
- **Websites:** CDA has posted educational material about EAB on their website: www.EABColorado.com. A website was created for Boulder specific EAB information at: www.EABBoulder.org and a hub to engage the community specifically on EAB and resiliency was created at www.resilienttogether.org/emerald-ash-borer.
- **News Releases:** The CO EAB Response Team and City of Boulder have distributed over 30 news releases and handled over 100 media requests since the EAB discovery.
- **EAB Workshops:** Boulder Forestry hosted a series of EAB Identification and branch peeling workshops in 2013, 2014 and 2015 and a series of EAB Van Tours in 2016 and 2017. The interagency group has trained over 550 foresters, arborists, and landscape professionals from six states on EAB symptoms and branch peeling techniques.
- **Presentations:** EAB presentations to Parks and Recreation and Environmental Advisory boards, the Downtown Management Commission and City Council. Meetings with over 30 local HOA groups to discuss EAB management;
- **Open Houses:** Hosted three EAB specific open houses for the public in 2014 and provided EAB tables at the two UFSP open houses in 2017 and 2018 and informational tables at Farmers Market and McGuckin's on multiple occasions.
- **Educational material produced:** Emerald Ash Borer Quick Guide, EAB Decision Matrix, Revised Edition of Insecticide Options for Protecting Ash Trees from EAB, Colorado specific EAB FAQ's, EAB identification cards, utility billing inserts, and RTD bus advertisements.
- **Launched TreeOpp program:** Community awareness/engagement wood utilization program repurposing ash wood into lumber, art, furniture in partnership with BLDG 61, Bridge House and ReSource.
- **Tree Give away and sales:** Launched first annual Boulder Tree Recovery Program in 2017 with support from National Arbor Day Foundation - gave away ~250 1-5gallon trees to residents to plant on private property. Facilitating and subsidizing the sale of 15 gallon trees to residents in 2018 and beyond.
- **Seedlings for BVSD 5th graders:** Each spring Boulder Forestry provides a short educational presentation to BVSD 5th graders on the importance of our urban tree canopy, the potential impacts of EAB and explains how they can make a difference. Each student also receives a seedling tree to plant for future generations to enjoy.
- **Tree Planting Events:** Hosted multiple community volunteer tree planting events since 2013 at locations around the city.
- **Tree Trust:** Partnered with the PLAY Boulder Foundation to launch a Tree Trust.
- **Home and business owner contacts:** Reaching out to individual residential property owners and downtown commercial business owners as opportunities arise to replace declining public ash trees though letters, door hangers and newsletters.

Tree Replacement

A variety of tree species, including western catalpa, hackberry, swamp white oak, London planetree, English oak, and sugar maple are among the species recommended to replace ash and increase diversity in the urban forest. Since ash removal began, Boulder Forestry has decreased the percent of public ash from 17 percent in 2000, to 14 percent in 2005, to 12 percent in 2015 through diversification in replacement efforts (Chart 11).

From 2014 through 2017, Boulder Forestry planted 1,935 trees in city parks and public street ROW in support of Boulder's no-net-loss canopy goal. Efforts were made to plant trees in neighborhoods most heavily impacted by EAB. The UFSP is proposing a goal for Boulder Forestry to plant 600 new trees annually. It is important to note that the success of newly planted trees requires a strong commitment to a frequent and effective pruning rotation cycle.

Chart 11: Ash as % of Public Trees



Boulder is planning a Spring 2018 tree sale of 15-gallon trees with tree costs subsidized via Public Works Water Conservation, the Climate and Sustainability Division and the Parks and Recreation Department. Boulder is also continuing the National Arbor Day Foundation Tree Giveaway of seedling trees through the Natural Disaster Recovery Program.

To kickstart the no-net-loss canopy strategy on private property, Boulder Forestry mailed letters to property owners in neighborhoods heavily impacted by EAB, encouraging property owners to request trees through the Boulder Forestry tree planting program. Letters were sent to property owners with good planting sites, including those with enough public ROW to support a large-maturing tree, an irrigation system, and no overhanging trees. The letters included information about Boulder's tree replacement program and the benefits of urban tree canopy and offered to plant a tree in the ROW adjacent to the home for free.

Even prior to the EAB detection, Boulder Forestry had begun to reduce the percent of public ash due to improve tree diversity. The overall percent of public ash decreased from 17% in 2000 to 15% in 2005 to 12% in 2013 through selective removals and diversification in replacement plantings.

Wood Debris Management

With the discovery of EAB in 2013, Boulder became an EAB quarantined community, where hardwood wood waste from the community was required to be disposed of in designated areas within and on the border of the County. Also, it is a violation of state and federal law to improperly dispose of wood waste. All UFRs generated through maintenance operations are diverted from the landfill. Wood utilization options that have been implemented or explored include:

- TreeOpp: Boulder partnered with BLDG 61 Makerspace at the Boulder Public Library to provide expert woodworking training for participants in Bridge House's Ready to Work program. The program teaches participants to turn EAB-infested wood debris into crafts, furniture, and functional products, for purchase by area residents;
- Biomass: Boulder entered into an agreement with Boulder County to utilize chips from whole trees as a quality heating fuel. Boulder County owns and operates two heating systems (biomass fueled boilers) at the Boulder County Parks and Open Space facility in Longmont, as well as the Boulder County Jail in Boulder that burns woody biomass to heat its buildings;
- Mulch/Composting: Tub grind logs into mulch, which is then utilized within the city park system or moved off-site for composting;
- BioChar: Charcoal is used as a soil amendment to improve soil quality. Biochar is a stable solid, rich in carbon, and can endure in soil for thousands of years. Biochar can increase soil fertility of

acidic soils (low pH soils), increase agricultural productivity, and provide protection against some foliar and soil-borne diseases; and

- Lumber: Higher quality logs are set aside for local sawmill operators to mill for furniture or flooring or to sell to the public via ReSource.

The EAB quarantine makes it illegal to move any hardwood firewood outside of Boulder County due to the difficulty in identifying ash from non-ash after it has been cut to firewood size. All residents cutting firewood must sign a liability waiver and agreement stating wood will not be moved outside of Boulder County.

Department Strategy and Collaboration

Boulder's EAB Interdepartmental Strategic Team works to identify and implement long-term strategies to manage EAB on a citywide scale and to ensure consistency across departments. The team includes representatives from the departments of Open Space and Mountain Parks, Public Works, Transportation, Planning, Greenways, Risk Management, Police and the City Attorney's Office.

Boulder developed a delimitation survey that found EAB in several neighborhoods in central Boulder. The site area was divided into 38 one-square-mile grids and ten trees were selected randomly in each grid for inspection. Additional trees were sampled in high-impact areas. For each selected tree, two branches were removed, and then examined by extension agents by painstakingly peeling each log into paper-thin layers using a draw knife. The city successfully identified EAB in several grids, and has updated its findings with continued research. Currently, EAB is expected to be present everywhere in the city.

Initial EAB management actions included news releases, website postings, HOA meetings, educational materials, workshops, and television interviews. Over the next two to five years, EAB will have a significant direct budgetary impact on Boulder and private residents. Unless immediate actions are taken to replace the anticipated loss to canopy (~25 percent of existing canopy), the transformed canopy will have considerable economic, social, and environmental impacts for decades. Because the majority of the trees in Boulder are on private property, tree replacement will require a coordinated effort between Boulder Forestry and the community.

All untreated ash trees on both public and private property and naturalized areas along the creeks and ditches are expected to die from EAB over time. Since EAB detection, Boulder has planted over 1,900 new trees in city parks and street ROW. A canopy loss of up to 32 percent is expected in some Boulder neighborhoods due to EAB. Although considerable, the overall loss to the city urban tree canopy is not as great as expected losses in other Front Range communities that are predominantly green or white ash.

Boulder Forestry staff participate in the emerging pests in Colorado (EPIC) working group and the Colorado EAB response team to share strategies, conduct workshops, develop templates for management plans, and keep apprised of advances and challenges in pest detection and management.

The EPIC committee includes city foresters from Denver and Fort Collins, as well as input from other relevant regional agencies. EPIC's goals are to increase cooperation and communication around emerging pests and diseases. This endeavor includes public education and outreach, which is a crucial component of EAB management, through workshops and the development of management plan templates.

Over the next few years, proposed EAB management strategies, including tree removal, tree replacement, wood disposal, and pesticide treatments, will continue to have a significant direct budgetary impact on Boulder and private residents.

Commercial Tree Program

Boulder's Commercial Tree Program (CTP) monitors and maintains public trees in the downtown area and other commercial areas throughout Boulder, including sidewalk treatments (tree grates, tree pits, and pavers) associated with those trees.

The program only receives funding to provide services for the downtown trees, which includes: installing and maintaining tree grates (construction of supporting frames, leveling grates and pavers with surrounding sidewalks to minimize trips, expanding grate rings to allow for tree growth, and repairing or replacing broken panels or guards), installing tree guards as needed for tree protection, tank watering of trees without supplemental irrigation systems, tree replacement, and negotiating with commercial property owners to improve site conditions.

In 2000, Boulder Forestry collaborated with the Planning Department to revise the design and construction standards for tree grate construction to standardize the sizes and styles of grates and to require the installation of supporting frames. Funding was granted to the program in 2005 from patio lease revenues to allow for hardscape repairs, and additional funding was added in 2008 at the request of City Council to include tree replacements in the downtown area.

Tree Inventory and Asset Management

One of the key themes from BPRD's recent Master Plan is, "Taking care of what we have." Through the development and implementation of an Asset Management Program (AMP), the department intends to manage data and provide support for all facets of Forestry operations. The result will be a well-informed organization that prioritizes decisions and resources supported by a robust database.

In anticipation of the transition to an AMP in 2012, Boulder purchased DRG's TreeKeeper® asset management software to consolidate the tree inventory and improve tracking for tree maintenance activities. Forestry staff rely heavily on TreeKeeper®'s mobile applications for data collection. Despite the benefits of the software, there is currently no option for offline data collection (cellular connection in West Boulder is spotty).

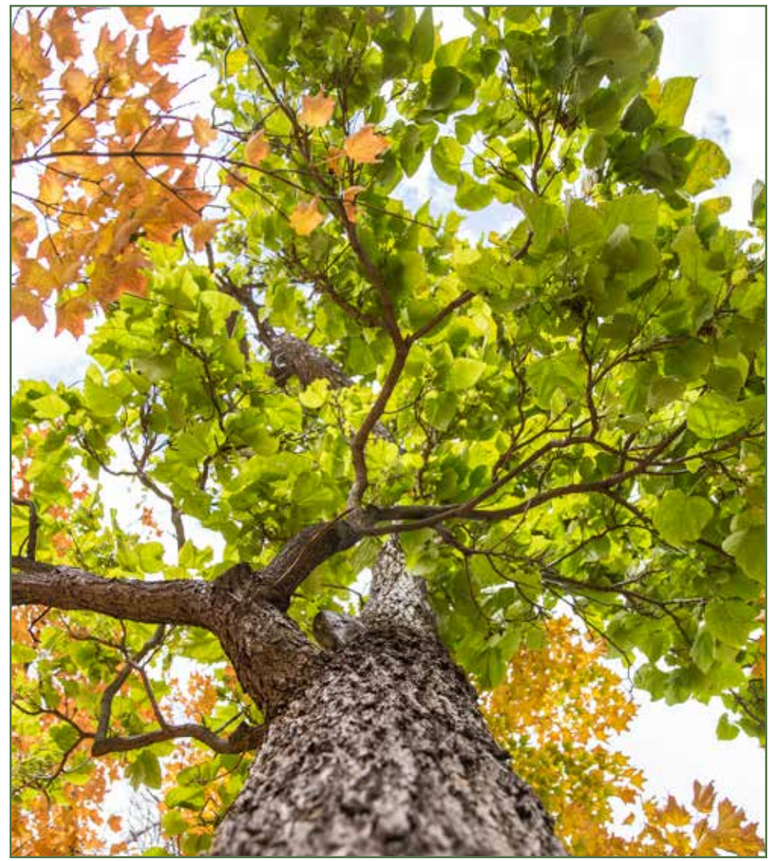
Over the past 30 years, the number of public trees has increased steadily. In 1987, the original public tree inventory was collected in a spreadsheet format and contained information on 27,000 trees. An update in 2000 included 36,000 public trees, where the addition of location data provided the first tree layer for Boulder's GIS program.

The most recent inventory update (2015) collected data on 50,800 trees and included additional data fields to track tree grates and guards, along with pest and disease metrics that will inform long-term strategy for EAB management and the UFSP.

Because trees vary considerably in life expectancy, growth habit, and maintenance requirements, an accurate inventory is crucial for strategic planning. Asset management is used to track the status and history of each inventoried asset, including new and replacement plantings, tree condition, maintenance needs, work history, and individual tree reports and photographs.

On a broader scale, the software can help plan maintenance operations and provide analysis for species diversification and budgeting for tree-related expenditures. In addition to a current inventory, it is also important to maintain up-to-date maintenance records on each tree for liability purposes and budget tracking. There is also a public interface that includes valuable calculations on environmental services provided by each public tree.

For logistical reasons, Parks and Recreation (including Forestry) is transitioning to a partnership with Utilities to use a single citywide asset management system (Beehive).



Development Review, Tree Protection, and Mitigation

Planning and Forestry staff works closely together to review development proposals, including single-family residential, multi-family, mixed-use, and commercial development. All new development and redevelopment projects that meet specific minimum thresholds are required to provide street trees. Forestry staff reviews development landscape plans to ensure compliance with Design and Construction Standards (DCS). Recommendations are provided for species selection and spacing, removal of undesirable trees, methods to minimize impacts during construction, and tree value appraisals for desirable trees that are scheduled for removal.

The development process includes “by-right” projects that request no modifications to the land use code and “discretionary” review projects that do request modifications. Discretionary review may be approved by city staff, the Planning Board, or City Council, depending on the specific request. Coordination occurs throughout the process and includes:

- Requests to remove trees through a development review process;
- Project specific and appropriate tree protection standards;
- On-site inspection pre-construction to determine feasibility of preservation, assess conditions, and determine specific requirements associated with protection/preservation;
- On-site inspection during construction to assess tree protection and condition changes;
- On-site inspection post-construction to review damage, mitigation and condition;
- Private tree assessments for development review projects when needed to support staff concerns or discrepancies in arborist supplied tree inventories;
- Requests for project history to determine obligations of private property owners;
- Maintaining tree inventory for removals and new planting;
- Planning staff typically recommends and reviews tree species selections, but does ask Forestry staff for input as needed; and
- Subject area experts as needed.

Forestry also responds to requests from adjacent private property owners (especially single-family residential). These requests include:

- Determination on whether a tree is public or private;
- Requests to remove public street trees (outside of a development review process); and
- Tree appraisals for construction projects and enforcement issues (outside of development review).

Mitigation fees are tracked through Boulder’s software and account payments systems. Planning staff typically adds the amount due under a building permit and the responsible party can pay the Planning and Development walk-in service counter, which ensures consistent accounting history.

Silva cell installation on Pearl Parkway for the Boulder Junction project.

All new development and redevelopment, meeting specific minimum thresholds, are required to provide street trees.

Challenges to the existing process typically occur around city projects that are not subject to the DCS or Title 9 standards. This includes inconsistency in Boulder Forestry's role and authority to make determinations on tree removal. For permitted projects (e.g., civic area redevelopment, private developments), Boulder Forestry is responsible for evaluating trees that will potentially be impacted by the project.

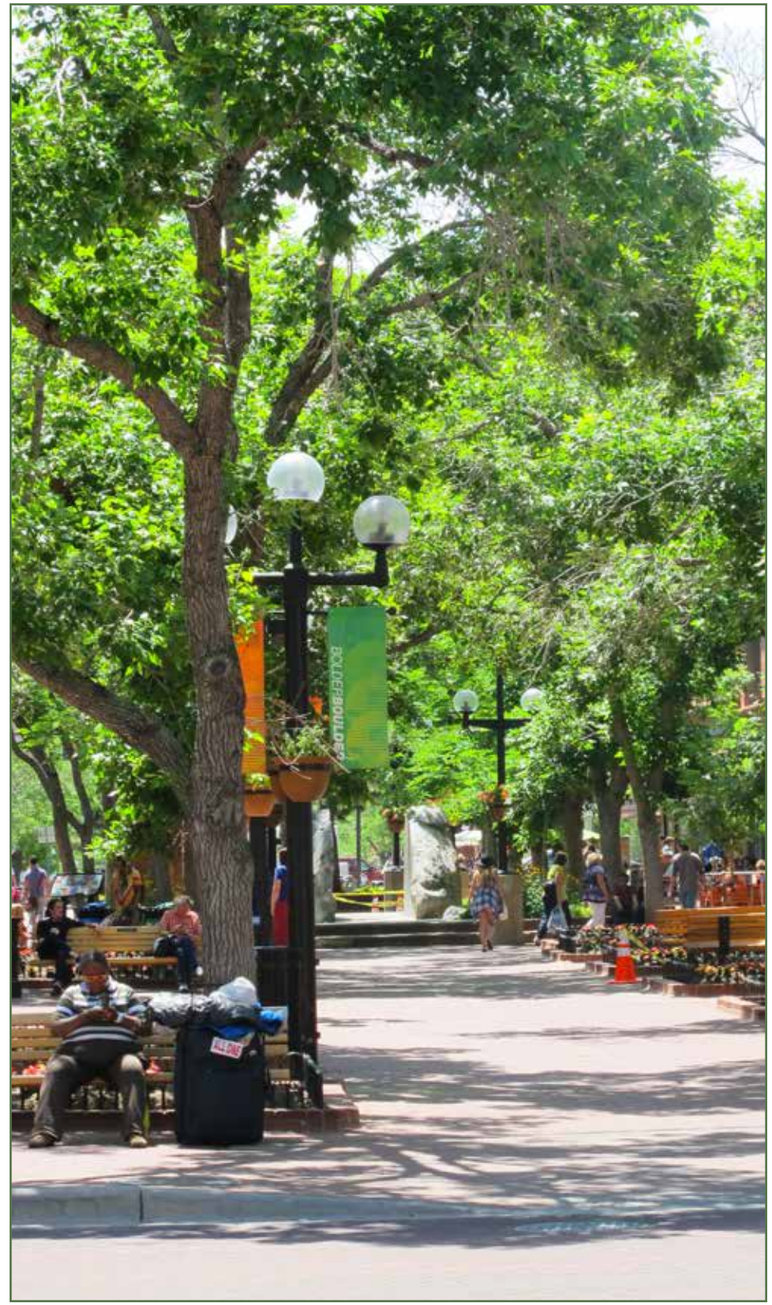
The actual decision to remove individual trees is up to Boulder's project managers, not Forestry, and there is no requirement for justification. For non-permitted projects (e.g., playground refurbishments) Forestry takes a more active role in determining removal for individual trees.

All transportation capital projects coordinate closely with Forestry and staff has the opportunity to provide input on tree removal and replacements. Yet, ultimately tree planting and removal decisions are made by the project managers.

Other challenges include:

- Current DCS are outdated in regard to application to city projects, tree species, planting specifications and diversity. They allow only small-maturing trees to be planted into ROW strips less than six feet.
- Inefficient tracking and communication between work groups.
- Construction oversight for tree protection and additional landscape review taxes Forestry staff and siphons resources away from core Forestry programs, such as the TSIP, CTP, IPM, and Rotational Pruning.

Fixed-term staff was hired in both Public Works and Parks and Recreation to manage the construction aspects for additional CIP projects after the 2011 Bond initiative, but most projects had both existing public trees within the project area and new landscape planned. Construction oversight for tree protection and additional landscape review taxed Forestry staff for several years and took resources away from core Forestry programs such as the TSIP, CTP, IPM and Rotational Pruning.



Enforcement of Tree Regulations

B.R.C. Chapter 6. Section 2 Removal of Dead, Diseased or Dangerous Trees allows city staff to conduct enforcement efforts on private property to address infested, diseased and/or dangerous trees. During summer months, Forestry staff surveys all city parks, streets, and alleys to identify diseased and dangerous trees on both public and private property. When forestry staff identifies a violation, a compliance case is initiated, and the property owner is notified with a first class letter. Forestry staff works with the Boulder Police Department and the city attorney's office to address issues of non-compliance. Before a tree care contractor can enter private property to remove a diseased or dangerous tree, the city must obtain an administrative warrant from the court. The cost of tree removal is billed to the property owner and, if needed, a lien placed against their property taxes. Existing feedback from the community is that Boulder Forestry must be more proactive in communication to allow property owners more time for tree removal before the trees becomes a high risk.

Over the next several years, the number of dangerous trees is expected to increase significantly as ash trees are killed by EAB. Research indicates that ash trees killed by EAB dry out and start to fail within a few years after tree mortality, posing a public safety risk. Discussions with the City Attorney's office, Risk Management, and Boulder Police Department, indicate Boulder has a duty to enforce city regulations for dead ash trees located on private property but that have the potential to threaten public property. Boulder is not proposing to implement enforcement efforts on private property where the trees only pose a threat to neighboring private property.

Between 2010 and 2015, Forestry enforced on an average of 20 properties each year to address diseased trees and an average of 25 properties for dangerous trees that posed a threat to public property. In 2016, that number increased to approximately 100 trees for dangerous trees, mainly due to EAB and dead Siberian elms from the 2014 freeze event. In 2017, the number of enforcements was just under 150 trees.

The ordinance currently allows Boulder Forestry to give the property owner "fifteen days from the date of the notice or such shorter time as the manager finds appropriate in view of the nature and extent of the condition." Local tree care companies have experienced significant increases in requests for work and have been unable to remove trees within the 15 days required by the ordinance. In many cases, it has taken 30+ days to get these dying/dead ash trees removed, thereby increasing public safety concerns. To minimize risk, starting in 2018, Boulder Forestry will enforce on private property ash trees with less than 50 percent crown symptoms. Removing symptomatic ash while still green should also lower removal costs as ash trees that exhibit >50 percent crown symptoms must be removed with specialized equipment that increases removal costs.

Ash trees along Greenways pose another concern. Green ash is naturalized (to various degrees) along all creeks and ditches in Boulder. With the exception of Boulder Creek Path, Public Works manages trees along bike paths adjacent to Greenways, therefore, Boulder Forestry does not currently survey these areas for dangerous trees. Due to the proximity of bike paths, tree removal or enforcement should be expected (depending upon whether it is public or private property) as trees die.

It is anticipated that current staffing levels, even as supplemented by contractors, will not be sufficient to support enforcement efforts as EAB reaches its peak.

Arborist Licensing and Staff Training

Boulder Forestry is recognized for their expertise and proactive approach to urban forest management. To better protect all trees, a licensing program was created to ensure that all tree work (public and private) performed within the city limits of Boulder is conducted to the same standards. Forestry and Planning staff work collaboratively to manage the city arborist licensing program for tree care contractors to ensure the following:

- All tree work within the city is performed in a safe, professional manner and according to industry standards;
- All persons/companies performing tree work within the city have the necessary insurance;
- All diseased/infested wood is disposed of in a proper manner to prevent the spread of insect or disease problems; and
- Maximize environmental services are derived from the Boulder urban forest.

To ensure that outside contractors meet these expectations, Boulder created a two-tier arborist licensing program:

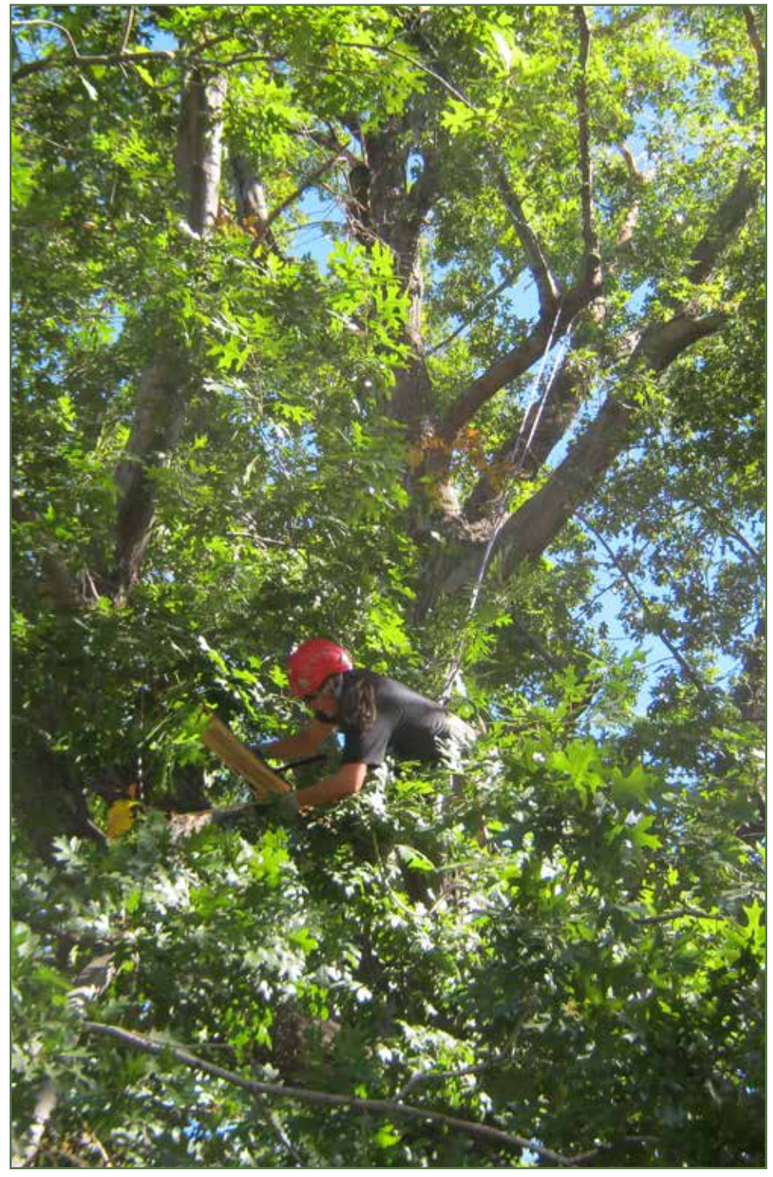
1. **Certified Arborist License** – for all International Society of Arboriculture (ISA) certified arborists or professional-level tree care companies. Licensees in this category have demonstrated a higher level of knowledge and professionalism and are allowed to perform tree work to trees in the public ROW and to both public and private trees that are infested/infected with a major insect/disease problem such as EAB, TCD of black walnut, DED, drippy blight of red oaks, Mountain Pine Beetle, etc.
2. **Tree Contractor** – for all persons or companies performing tree work that are not ISA certified or choose not to test through the city. Licensees under this category are not allowed to perform tree work to trees in the public ROW or to public or private property trees that are infested/infected with a major insect/disease problem.

Under this program, any person or company performing work to either public or private trees (tree pruning and tree removal) within city limits must be licensed in one of two categories; certified arborist or general tree care contractor. Forestry staff administers testing and annual training and provides updates on city standards for licensed arborists.

There are some recognized limitations to this program, including:

- No requirement to show proof of safety training;
- The current two-tier system is confusing to the public and stakeholders believe the system should be only one tier (the top tier); and
- No effective enforcement mechanism for ensuring compliance with this requirement.

The application process requires numerous modes of contact, including an e-mail address, and the city is progressing towards multilingual options for all information. Boulder Forestry would like to increase contact with licensees through meetings, newsletters, and training in hopes of further strengthening the high-quality standards of tree care in Boulder.



Emergency Storm Response

Boulder Forestry often responds to emergencies involving trees. This includes public trees that have been damaged by storms or high winds, involved in automobile accidents, and vandalized. Forestry also responds if a private tree falls or drops branches into the ROW. During and immediately after major storm events, Forestry staff conduct comprehensive surveys to identify and prioritize work, including pruning and removal, to provide clearance and ensure public safety in the ROW. Forestry and Public Works collaborate to complete the cleanup. Forestry staff remove damaged branches in trees and Public Works removes downed trees and branches. In large storm events, the city engages contract crews to assist with cleanup and debris removal.

Although Forestry and Public Works coordinate regularly during large storm events, there is no formal emergency response protocol. Sometimes there has been confusion and misunderstanding of Forestry's responsibilities and priorities. As a result, Public Works and Forestry have each expressed the desire to review policy and develop protocols to address emergency response, including storm calibration and plans for the mobilization of equipment and personnel.

Communication, Public Outreach, and Notification

As a part of normal operations, Boulder Forestry maintains active communication lines with multiple audiences, including the Boulder community, other city departments, green industry leaders, woodworkers, regional foresters, and city, state and federal agencies.

The city primarily communicates with residents through established outreach programs, including, the Boulder Forestry Newsletter, Emerging Pests in Colorado (EPIC), and the Colorado EAB Response Team. Methods of communication include email, workshops, door hangers, mailed postcards, news releases, public meetings and workshops, research tours, online resources, and farmer's markets and other community events. Community engagement activities that are organized to be inclusive and inviting to all Boulder community members include:

- Articles in local newspapers volunteer-led tree plantings in city parks;
- Annual Arbor Day celebration;
- Tree give-away program;
- Seedling giveaway for BVSD fifth graders at the Water Festival;
- Fall photo contest;
- Online self-guided notable tree tour and accompanying application for Snow Much Fun Scavenger Hunt;
- Map your ash tree and replacements; and
- Citizen science project with 100 Resilient Cities.

Door hangers are the primary method used to notify adjacent property owners of upcoming tree care operations on their street. Due to the high percent of rental properties, Boulder Forestry must also send letters to property owners in addition to the door hangers. Notification is extremely challenging given the number of rental properties.

Successful outreach campaigns find ways to give notice to both owners and managers in addition to tenants. For high profile projects and when major traffic disruptions are scheduled, Forestry employs additional methods to reach concerned stakeholders, including news releases, social media, flyers, and website resources.

Forestry coordinates with local tree care professionals to provide updates to bid and contract requirements, information and updates on emerging pests and disease treatment strategies, and goals for improving species diversity.

Regionally, Boulder Forestry participates in the Emerging Pests in Colorado (EPIC) working group and the Colorado EAB Response Team to share strategies, conduct workshops, develop templates for management plans, and keep apprised of advances and challenges in pest detection and management.

Boulder Forestry recognizes the importance of outreach and collaboration with stakeholders and understands that key messages need to be tailored to the individual needs and concerns of different groups. Stewardship of the urban forest requires the commitment and engagement of the entire community, especially in the face of managing and recovering from the devastation that is occurring with the invasion of EAB. Forestry staff and stakeholders have identified opportunities to improve outreach and communications strategies, including:

- Updated door hangers, including new messaging to increase EAB awareness;
- Better and more proactive methods for communication with property owners for tree removals on private property;
- Website elements to better engage youth and schools;
- Increased use of online story maps and other graphic tools to promote awareness of EAB, planting goals, and other key messaging;
- Additional contests and events to connect the community with the urban forest; and
- Stronger EAB messaging so that the public has clearer idea of impacts.

Public Service Requests

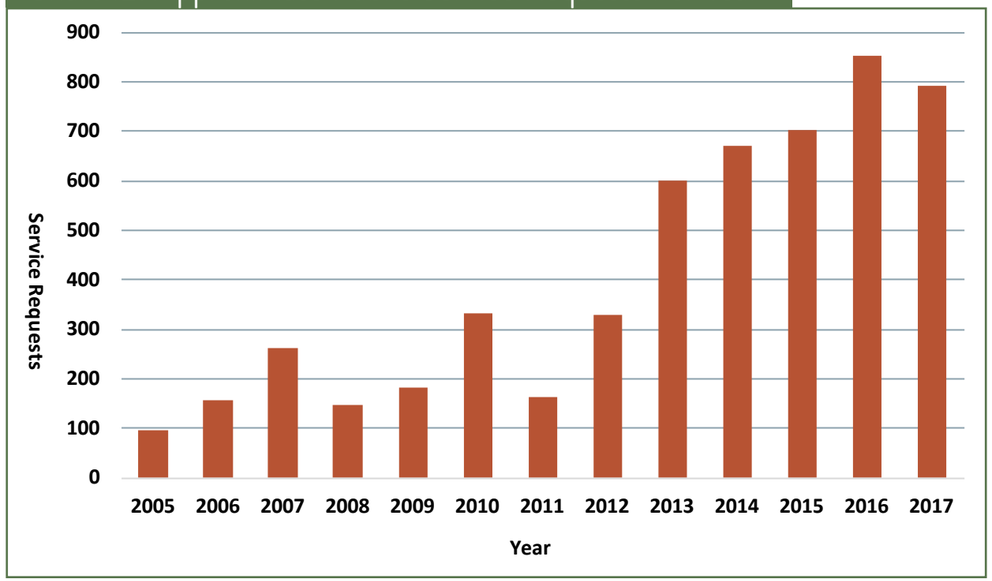
Public service requests are submitted through an online portal and have been steadily increasing since 2013. Prior to EAB detection, Forestry received an average of 210 requests per year. From 2013 through 2015, the average was 659 requests per year. In 2016 and 2017, Boulder Forestry received 853 and 793 requests for service (Chart 12). These values do not include the 1,621 emergency response requests since 2010. In addition to online service requests from the public, Forestry also addresses internal and jurisdictional requests.

Several factors contribute to the increase in service requests, such as pest problems including EAB and drippy blight of red oak, deferred maintenance and suspended pruning cycles, and a rise in requests for clearance and safety pruning. Severe weather has also played a role, including the deep freeze that occurred in November 2014, killing more than 500 Siberian elms on public property and spring snow storms in 2016, which also caused significant damage to public trees.

Currently, Boulder does not track the rate of service requests generated from planning staff. For example, there is no historical record of additional reviews, construction oversight, tree appraisals, or inspections. Without this record, tracking changes over time to create financial forecasts is difficult.

Previously, the turnaround for responding to service requests was one week. Following the detection of EAB, response time increased to two weeks. Currently, the response time for non-emergency requests is one month.

Chart 12: Approximate Public Service Requests Per Year



Wood Utilization

Across the United States, large amounts of urban forest residues (UFR) in the form of wood chips, brush, logs, and leaves are generated by landscape maintenance and tree care companies, homeowners, and municipal tree care operations. This debris can have a big impact on landfill operations and mismanagement of infected debris can increase the severity and spread of pests and disease.

Prior to 2005, when TCD of walnut was identified in Boulder, Forestry hosted an annual firewood sale. The sales generated little revenue but were successful at reducing UFR and disposal costs.

When pest infestations made firewood sales impractical, logs were ground into mulch that was then used in city parks or moved off-site for composting by an outside vendor (A-1 Organics in 2014-2016). The grinding and haul away costs for this program were over $35,000 in 2016 alone and are expected to exceed $50,000 in 2018.

In 2014, Boulder entered into a memorandum of understanding with Boulder County to utilize chips from whole trees as a quality heating fuel. Boulder County owns and operates two biomass fueled heating systems at the Boulder County Parks and Open Space facility (Longmont) and the Boulder County Jail (Boulder) that burn woody biomass to heat their facilities. This mutually beneficial program supplies the county with a source of locally generated biomass and provides a sustainable use for the UFR generated by Boulder Forestry operations.

In 2016, a grant from the Knight Cities Foundation allowed Boulder to partner with Bridge House and BLDG 61 Makerspace, to develop the TreeOpp program. Bridge House is a local nonprofit that assists individuals experiencing homelessness. TreeOpp trains and employs local artisans that tutor apprentices in conjunction with Bridge House's Ready to Work program. TreeOpp uses wood from ash tree removals to create marketable products for the community, including furniture and crafts.

Today, all UFR generated from Boulder Forestry operations is transferred to Forestry's log yard, where staff strive to use only sustainable practices and minimize the amount of UFR entering landfills. Since 2000, only two truckloads of wood infected with DED were diverted to the Erie landfill. All other UFR was successfully diverted to other use.

Many cities have realized there is no single long-term solution for managing UFR, and, considering the high volume and low quality typical of UFR, identifying sustainable uses is an ongoing challenge. A suite of plausible options is crucial to effectively manage debris and minimize costs.

Funding for Forestry Operations

A stable budget allows urban forest managers to program necessary tree care at the appropriate life stage when it is most beneficial and cost effective. Public trees are a vital component of Boulder's community infrastructure. Unlike most components, including buildings, and pavement, the value and services provided by a tree generally appreciate over time. To realize this potential, specific maintenance tasks must be coordinated at critical life stages.

Trees are living organisms, constantly growing and changing over time and in response to their environment. There are a number of factors that affect tree health and structure, including nutrition, available water, pests, disease, wind, and humidity. While it might seem like most changes to trees take a long time to occur, some specific maintenance is critical at certain stages of life. For instance, young trees benefit greatly from early structural pruning and training. Major structural corrections can be applied easily and at a low cost when a tree is young.

Unfortunately, if left unattended poor structure can evolve into very expensive issues and increase liability as a tree matures. At which point it may be impossible to correct the issue without causing greater harm.

As a public tree nears the end of its useful lifespan, planning and budgets should provide consideration for more frequent inspections and eventual removal and replacement.

Operating Budget

The annual budget for forestry operations is funded through four primary sources; the General Fund, the Parks and Recreation $0.25 Sales Tax Fund, the Capital Improvement Program (CIP), which provides limited-term funding to address specific goals, and through reimbursement for trees removed through development (Tree Mitigation. In 2017, the overall budget for forestry was $1,258,335, including $220,000 in CIP funding to address EAB management (Table 8).

A Tree Cost Estimate formula was developed by Boulder Forestry to determine the cost to maintain Public Works trees which includes: the cost of replacement planting, rotational pruning, pesticide applications and removal. The formula can be adapted for the different life stages of a tree (Establishment, Growth, Maturity, Over Maturity) and can assume proactive management (10 year rotational prune, etc). The formula estimates that the 4,458 trees on lands currently under the jurisdiction of Public Works require annual maintenance costs of approximately $75,000 to maintain the trees.

Table 8: Operating Forestry Budget (2017)

2017 Operating Budget (Forestry)	$
Salaries & Benefits - Standard	$489,258
Admin - Supplies, Training, Cell Phones, Etc.	$33,604
Pruning	$167,700
Fleet	$105,000
Removals	$87,273
Commercial Tree Program (tree grates/guards)	$62,000
Salary - Seasonals	$70,000
Planting	$18,500
IPM	$5,000
Subtotal	**$1,038,335**
Capital Improvement Program (EAB)	**$220,000**
Total	$1,258,335

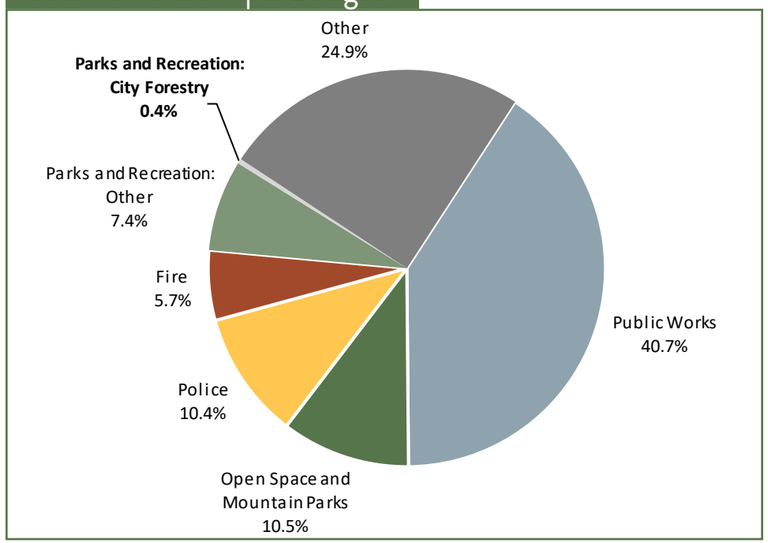
To put these costs in perspective, the overall budget for Boulder in 2017 was $321,866,000. Forestry's budget of $1,258,335 represents less than 0.4 percent of the overall annual budget for Boulder (Chart 13).

The General Fund and the Parks and Recreation Sales Tax fund provide the largest and most consistent funding for Forestry operations. Funding is dependent upon tax revenue and is subject to social and political will.

Since 2014, the Forestry budget has been supplemented annually with approximately $220,000 in CIP funding to address EAB management, including ash removals, pesticide treatment, tree planting, tank watering, and wood debris management. Previously, CIP funds have supported updates to the tree inventory. Funding from CIP is generally short-term in nature, intended to address specific issues and goals.

Since 2014, annual funding for forestry operations (including CIP) has increased by 9 percent. Excluding short-term CIP supplements, base funding for forestry operations has only increased from $880,000 to $1,038,335. Over that same four-year period, the U.S. dollar experienced inflation by 3.4 percent. As a result, the actual purchasing power of the forestry budget has decreased from 2014 levels.

Chart 13: Municipal Budget



Mitigation

Per ordinance, Boulder Forestry receives compensation for public trees removed or damaged through development projects, vehicular accidents, and vandalism. Funding is earmarked for public tree planting and establishment. The general Forestry budget contains enough funding to plant approximately 75 trees annually. The mitigation fund allowed Forestry to plant an additional 200-400 trees annually. However, the mitigation funding is sporadic and not a reliable source for long-term planning.

Donations

On occasion, the Parks and Recreation Department receives donations from individuals and organizations. BPRD maintains a list of specific projects that would benefit from donated funding for those who express an interest. Otherwise, donations are used at the discretion of the Director to best meet the current needs of the department, including forestry operations.

Most donations are one-time gifts and as such do not represent a consistent or sustainable funding source. Regardless, every donation is appreciated and acknowledged by a letter from the Parks and Recreation Advisory Board.

Funding Mechanisms in Various U.S. Cities

Special Assessments: One of the most stable sources of funding for urban forestry programs is the special assessment. Some states authorize cities to assess all property owners for specific public benefits and services such as sewer systems and public trees. The assessment can be levied as a fee per foot of ROW frontage or as a percentage of the property value.

Taxes: Many cities attain funding for urban forestry through special taxes. St. Louis, Missouri implements a property transfer tax and a sales tax (1/2 cent) to supplement forestry operations. Burlingame, California devotes a portion of a gas tax to urban forestry.

Capital Improvement Projects: A short-range plan, usually four to ten years, which identifies capital projects and equipment purchases, provides a planning schedule and identifies options for financing the plan. If trees are defined as capital assets, then funds can be allocated to the protection and management of trees during infrastructure and utility projects.

Development Fees: Private property owners in an area that will benefit from development may be required for a proportion share of the public infrastructure required to serve a development. Trees can be considered public facilities, and the costs to plant and care for them can be supported by these development fees.

Stormwater Fees: Stormwater fees are often implemented through an assessment to property owners to build and maintain stormwater infrastructure. The trees and vegetation of an urban forest help mitigate stormwater runoff and lessen the burden placed on conventional stormwater infrastructure. Communities like Milwauakee have recognized that the urban forest provides legitimate stormwater management activity and can be funded by such stormwater fees. With that level of recognition, Milwaukee recently approved a small increase in the stotrmwater fee, and earmarked it for urban forestry.

Biogenic Utility: A biogenic utility is a utility founded on the services provided by trees. The services can be calculated in dollars, pounds of pollution filtered, gallons of rainwater intercepted, tons of carbon dioxide avoided, and kWh of energy not used. Denver Water, in Colorado, is the utility organization that supplies drinking water to over a million people. Denver Water collaborated with the Forest Service, which signed a $33 million cost-sharing agreement for forest management and watershed restoration. The average residential water user will pay an extra $27 over the course of five years to match the Forest Service's $16.5 million allocation.

Funding Shortfalls

Ideal funding provides the resources necessary to support the quality services historically provided by Boulder Forestry and allows BPRD to meet community expectations for the care and maintenance of the urban forest. At current levels, funding shortfalls have significantly reduced Forestry's ability to provide regular maintenance to street and park trees. While funding has remained somewhat stable since 2014, EAB response and recent weather events have required managers to reallocate maintenance budgets to respond to these emergencies and reduce their impacts on public safety. As a result, pruning rotations have been extended beyond the previous interval of eight years (park trees) to ten years (street trees) (2012).

Deferred maintenance can be expected to have additional future impacts on operational budgets as trees that are neglected are more likely to experience damage and failure during extreme weather events. Neglected and storm-damaged trees are also less likely to realize their expected useful lifespan, reducing their overall services and utility to the community and reducing the overall benefit to investment ratio for the urban forest. More importantly, neglected trees increase risk exposure to

Table 9: Average Tree Care Costs (2012-2016)

Tree Size Class	Park Tree Pruning	Street Tree Pruning	Removals
1-7" Diameter	$104	$56	$142
8-15" Diameter	$105	$91	$245
16-30" Diameter	$203	$208	$605
31"+ Diameter	$379	$397	$1,287

property and public safety. Trees of different sizes have different needs for tree care. Boulder has calculated these average tree care costs (Table 10).

Industry standards in urban forestry suggest that cities should provide rotational pruning and general maintenance on a five to seven-year rotational cycle. Structural and clearance pruning may require shorter intervals for affected trees.

National Comparison

The most common primary funding mechanism used for urban forestry programs among municipalities in the United States is the General Fund (86%) (Hauer and Peterson, 2014). On average, the General Fund provides 71 percent of all funds used for forestry budgets.

On average, forestry budgets account for 0.52 percent of total municipal budgets. The average per tree budget is $31.67. By comparison, Boulder currently invests $20 per tree and less than 0.4 percent of the overall municipal budget (Table 10). The $20 per tree value was calculated from the routine operating budget ($1.04 Million) and does not include EAB CIP funding.

Fort Collins and Longmont, two other Colorado communities, are examined for context. Fort Collins has approximately 52,000 public trees and a total budget of $2.28 million. Longmont now manages 21,061 public trees, and has a base budget of $647,400.

The mean annual salary for highly-skilled Boulder city arborists is between $61,084 and $ 79,560. The United States Bureau of Labor Statistics collects data and regularly develops a mean of all occupations in the country. In 2014, the mean annual wage was $47,230 while the mean salary for a municipal field arborist was $47,837. Entry-level positions, seasonal workers, laborer, clerical, and truck driver jobs were lower. It is important to note that the cost of living in Boulder is 21 percent greater than the national average, suggesting that employee compensation should be correspondingly higher than communities with a lower cost of living.

On average, US forestry budgets are 0.52% of overall municipal budgets. To reach the average, Boulder would need an annual forestry budget increase of $497,735.

On average, US municipalities invest $31.67 per public tree. To reach the average, Boulder would need an annual forestry budget increase of $458,836.

Table 10: Boulder's Urban Forest Budget in Comparison with Other Communities

	Glendale (2005)	Bismarck (2005)	Cheyenne (2005)	**Boulder (2017)**	Longmont (2017)	Ft Collins (2017)	Berkeley (2005)	Average
Investment Per Public Tree	$13	$18	$19	**$20**	$31	$44	$65	$30
Total Forestry Investment	$276,436	$316,640	$327,897	**$1,038,335**	$647,400	$2,280,000	$2,372,000	$1,036,958
Total Public Trees (Street + Park)	21,481	17,821	17,010	**50,800**	21,061	52,000	36,485	30,951
Population	220,000	56,234	53,011	**107,167**	92,852	167,000	104,000	114,323

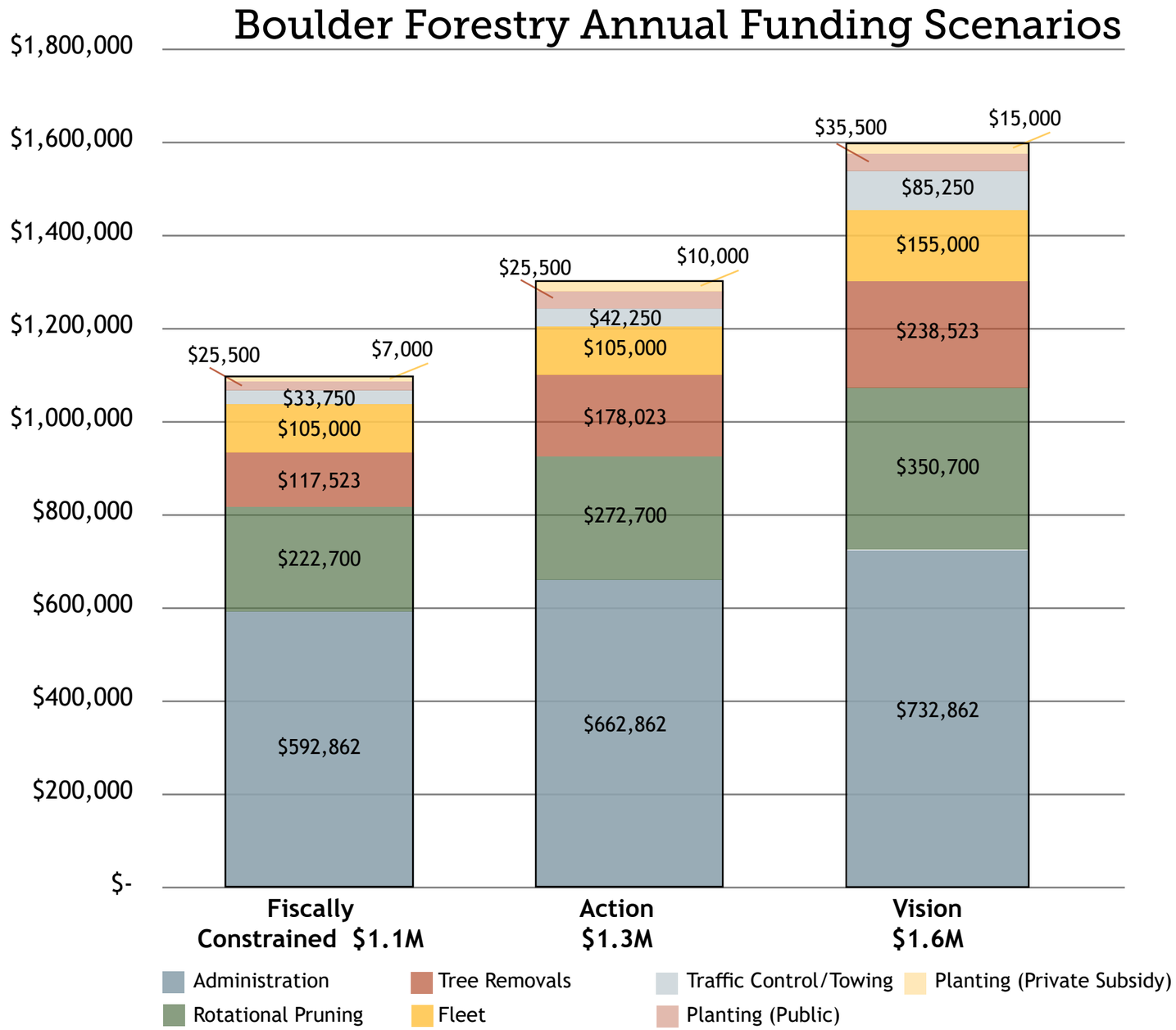
Proposed Budget

To provide the recommended core programs and responsibilities, Boulder forestry will require additional funding (Table 11).

Specifically, current funding levels are inadequate to support:

- Pruning and maintenance cycles: The industry recommendation is five to seven-year rotation;
- EAB management: The costs for treatment and removal will continue to rise over the next several years;
- Traffic control and towing costs are increasing: for some trees, the traffic control costs exceed the removal cost;
- A tree planting initiative to preserve Boulder's current level of tree canopy cover (16%): The initiative requires increasing public tree planting to 600 trees per year and facilitating 2,025 new trees on private property;
- Planting initiatives should include an increased level of young tree care. because proper watering and structural pruning are required to ensure young trees live to their fullest; and
- Public engagement and programming.

Table 11: Funding Scenarios



Threats to the Urban Forest

Climate Change and Severe Weather

Boulder's extreme weather will continue to impact the species of trees that can successfully establish and thrive in Boulder. Climate change will continue to be a factor due to changes in precipitation seasons and type (rain, ice, or snow), temperature fluctuations outside historic patterns, and changes in regional temperature norms. These changes blur the lines of established plant hardiness zones and the species that can be grown in a given region.

Around the world, foresters are reviewing plant material lists in a proactive effort to ensure that urban tree planting efforts result in increased resiliency and species diversity in anticipation of climate shifts and escalations in disease and invasive pests.

Storms, severe weather, climate change, and unusual weather fluctuations can cause significant damage and chronic stress in the urban forest, including:

- Snow buildup on branches during early fall or late spring snowstorms can cause excess weight on branches, which break or form internal cracks that further weaken branches;
- Cold snaps after trees have just broken bud can cause defoliation and damage to new tissues, requiring the tree to mobilize stored resources to leaf out again in a second flush;
- Extended periods of extreme cold can kill species that have thrived in the area for decades, effectively shifting the area into a different climate zone;
- Ice or snow settled in branch unions can cause tissue damage and potential for decay and cavity development;
- Severe weather can damage irrigation systems;
- De-icing chemicals can cause salt burn on foliage and create undesirable soil conditions. Prolonged exposure can reduce overall plant performance;
- Trees can fail in wind events and damage property or adjacent trees as they fail;
- Prolonged drought can cause summer defoliation and tree mortality if irrigation systems are not maintained or without adjustment to accommodate insufficient precipitation;
- High summer temperatures can increase transpiration rates and require increased irrigation regimes;
- Warmer winter temperatures may alter dormancy requirements;
  - Reduces the number of chill days, critical for trees to produce fruit/nut crops;
  - Alters reproductive ability because plants need to flower to reproduce. In order to flower, they need a trigger, which is usually a long winter chill; and
- People can see tree damage and develop concern for remaining healthy trees, leading to premature removal or unnecessary and overly aggressive pruning practices.

Extreme weather events can be a challenge to manage because of their unpredictable duration and frequency. Fortunately, urban forest managers do have some tools to prepare for, and reduce the impact of, severe weather. For example, there is a need for routine adjustments to irrigation to accommodate weather patterns. It is important to note that these adjustments are not always completed, especially on privately managed systems.

Some systems are controlled by smart irrigation controllers, which monitor evapotranspiration and adjust irrigation based on real-time data. Storm response and emergency preparedness plans can simplify storm response protocol and ensure coordination and collaboration among departments. The primary tool in the face of uncertain weather patterns is establishing a diverse composition of many species.

It's not easy being a tree; Severe Weather Events

Extreme weather events can be a challenge for Boulder; high winds, snowfall, flooding, and temperature fluctuations all pose threats to the health of trees. Tree-related costs for severe weather events are mainly due to post-storm clean-up and tree replacement.

Costs are often difficult to fully record. For example, the severe weather events in October, 2011 had an unknown additional cost for citywide branch clean up. The severe weather event in March and April of 2016 included an additional $375,000 in citywide branch clean up. Because these branch clean up costs are unknown or estimates, they are not included in the Boulder forestry cost values for those years.

Key strategies in the face of uncertain weather patterns include the establishment of diverse species composition along with proactive pruning. Collaboration and planning among departments is also vital. Emergency response plans are critical to effectively respond to severe weather events.

1990's	Boulder Forestry Cost	Type of Event
October, 1991	$51,250	Freeze
March, 1992	$32,045	Snow
September, 1995	$363,710 (Over 3 Years)	Snow
October, 1997	$7,000	Snow
February, 1999	$4,000	Wind
1990's Decade Total Cost: $458,005		

Freeze Damage

Freeze Damage

Snow Damage

2000's	Boulder Forestry Cost	Type of Event
September, 2000	$2,000	Snow
2002 through 2005	$122,660	Drought
March, 2003	$5,000	Snow
March, 2004	$5,000	Wind
June, 2004	$2,000	Wind
February, 2007	$2,500	Wind
June, 2007	$7,200	Wind
December, 2008	$4,500	Wind
October, 2009	$12,200	Snow
2000's Decade Total Cost: $163,060		

2010's	Boulder Forestry Cost	Type of Event
May, 2010	$1,500	Wind
October, 2010	$4,000	Wind
October, 2011	$50,000	Freeze and Snow
January, 2012	$29,000	Wind
May, 2013	No Data	Freeze and Snow
September, 2013	$25,000	Flood
November, 2014	$300,000	Freeze and Snow
March + April, 2016	$150,000	Freeze and Snow
2010's Decade Total Cost: $559,500		

Drought Damage

Wind Damage

Other Invasive Pests & Diseases

Invasive pests and disease, including EAB, are one of the most significant threats to urban forests around the world. The impacts from invasive pests can be both environmentally and economically devastating. Invasive pests are not new to the Boulder landscape. DED was introduced into Colorado in the 1970's and first discovered in Boulder in 1978. Over the past 40 years, Boulder has removed more than 1,000 American elms. Across Colorado, approximately 30,000 have been lost to DED. Other pests that have resulted in tree mortality in Boulder over the past ten years, or are expected to cause tree mortality in the near future, include: EAB, TCD of walnut, drippy blight of red oak, Japanese beetle, pine wilt nematode, and ips beetle in spruce.

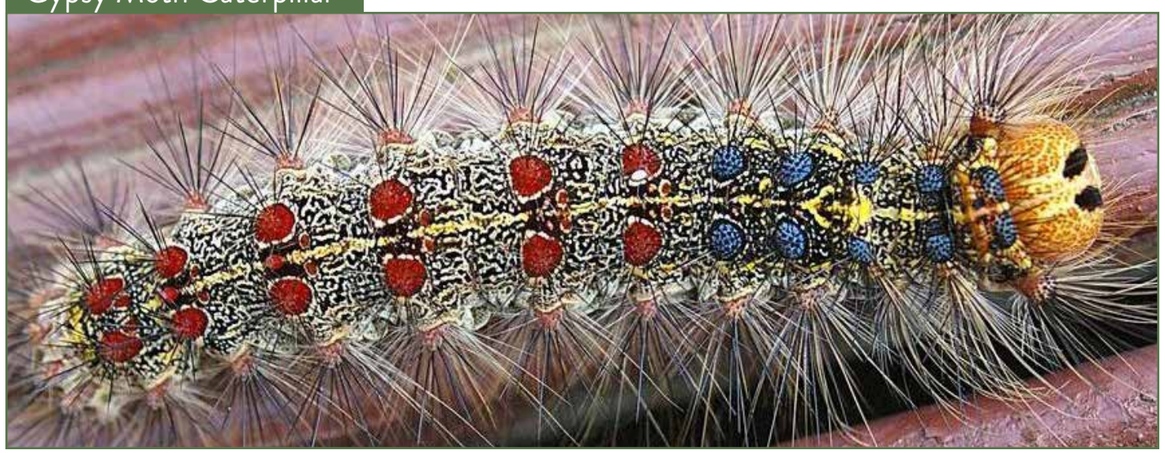
The urban ecosystem and insect/disease problems associated with it are constantly changing. Looking at the history of insect infestations in Boulder, it is likely that new insects that cause damage to Boulder's urban trees will continue to be introduced in future years.

Gypsy Moth

An additional threat to the Boulder landscape is the gypsy moth (*Lymantria dispar*). The moth was introduced to the Northeastern U.S. in the 1800s and has since steadily increased its range. Today, its distribution is primarily east of the Mississippi with outbreaks in Michigan and Wisconsin. The moth is the most important defoliating caterpillar in North America, affecting a wide range of shade trees and shrubs. Infestations could be especially devastating to trees already weakened by drought stress.

The moths are primarily transported in the form of egg masses attached to nursery plants, firewood, outdoor furniture, campers, or trailers that originate from areas where gypsy moth is present (Camper and Cranshaw, 2013). The gypsy moth has been introduced to Boulder and other parts of Colorado in the past and reintroduction is possible with a highly mobile population that could transport the eggs from gypsy moth infested parts of the country. Previously, gypsy moth spread in Colorado has been controlled through biological control, but control of this pest is dependent upon preventing introduction and early detection.

Gypsy Moth Caterpillar



Thousand Cankers

Thousand Cankers Disease

TCD currently threatens millions of black walnut trees across the U.S. The disease is caused by the combination of a fungus (*Geosmithia morbida*), which is vectored by the walnut twig beetle (*Pityophthorus juglandis*). The disease was first observed in Boulder in 2003 and is considered to be native to the southwestern U.S. Its range has expanded greatly over the past two decades (Sitz, 2017). Treatment or control measures have not yet been identified, but voluntary quarantine of suspected infected material is advised.

Detecting infection can be difficult. Sometimes the infection can persist for years with no external signs or

symptoms. Walnut twig beetles tunnel into the bark and introduce the fungus, which then kills an area under the bark, known as a canker. When the beetles are abundant, cankers can girdle twigs or branches, stopping the flow of sugars through the phloem, and causing yellowing, wilting, and branch die back. Trees under stress usually die within three years of initial symptoms.

Since 2003, approximately 900 walnut trees have been removed in Boulder due to TCD. There are less than 100 black walnut trees remaining in city parks and ROW and most are less than ten inches in diameter. Since the disease complex only damages a small area under the bark, the walnut wood can be milled and used to create useful and beautiful wood products.

Kermes Scale and Lonsdalea Enterobacteria

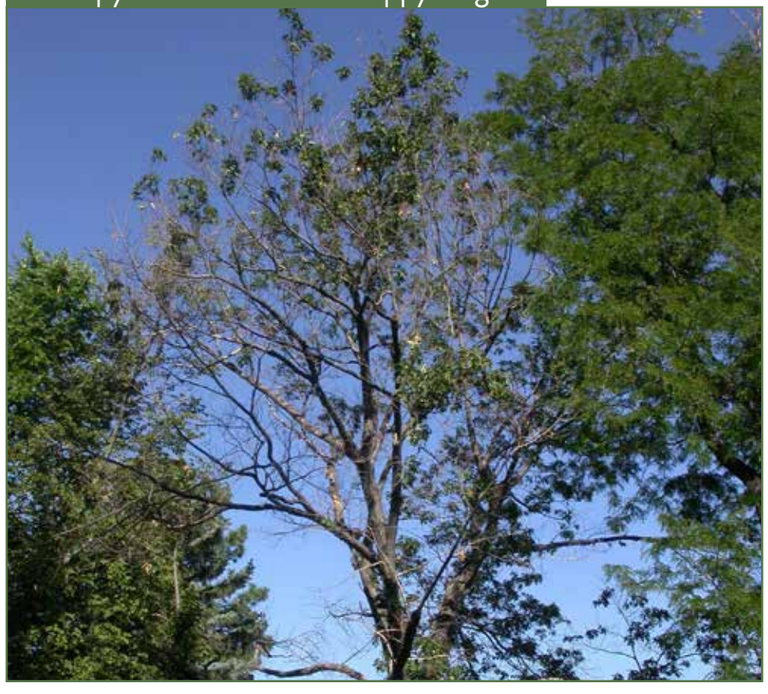
Kermes scale (*Allokermes galliformis*) is a common insect pest associated with northern red, pin, and gambel oaks (*Quercus rubra, Q. palustris, and Q gambelii*). Typical symptoms include reduced tree vigor and twig die back. Kermes scale alone is rarely fatal to trees.

In 2010, new symptoms, including sap weeping and dripping exudate, were observed on dying northern red oaks. Further testing found the scale associated with a bacterial pathogen (*Lonsdalea quercina*), which was infecting trees and causing the new symptoms.

Susceptible oaks account for 912 trees in Boulder's public tree inventory, but there are many more on private property. Boulder Forestry monitors public oak trees, providing pruning and removal as needed. Larger diameter red oaks were also sprayed with Ecotrol (rosemary oil) in 2016 in an attempt to control the scale. It is likely more mature northern red oaks will be removed unless a reliable, effective control can be found.

Signs of Drippy Blight

Canopy Dieback due to Drippy Blight



Kermes Scale

Emerald Ash Borer

EAB, a small metallic-green jewel beetle which feeds on ash trees, is thought to have been introduced to the U.S. in the mid to late 1990s through wooden shipping or packaging materials originating in China. It was first detected in Michigan in 2002 and since then has moved across the country to over 30 states and two Canadian provinces. To date, EAB has killed hundreds of millions of ash trees, and that number is increasing rapidly. Annually, EAB spreads only short distances (0.5 to six miles) through the natural dispersal and flight of adult beetles. EAB has also spread through the movement of infested material such as firewood.

North American ash trees have shown little resistance to EAB and it is widely considered to be the most destructive forest pest in North America, threatening all native ash trees of the *Fraxinus* genus.

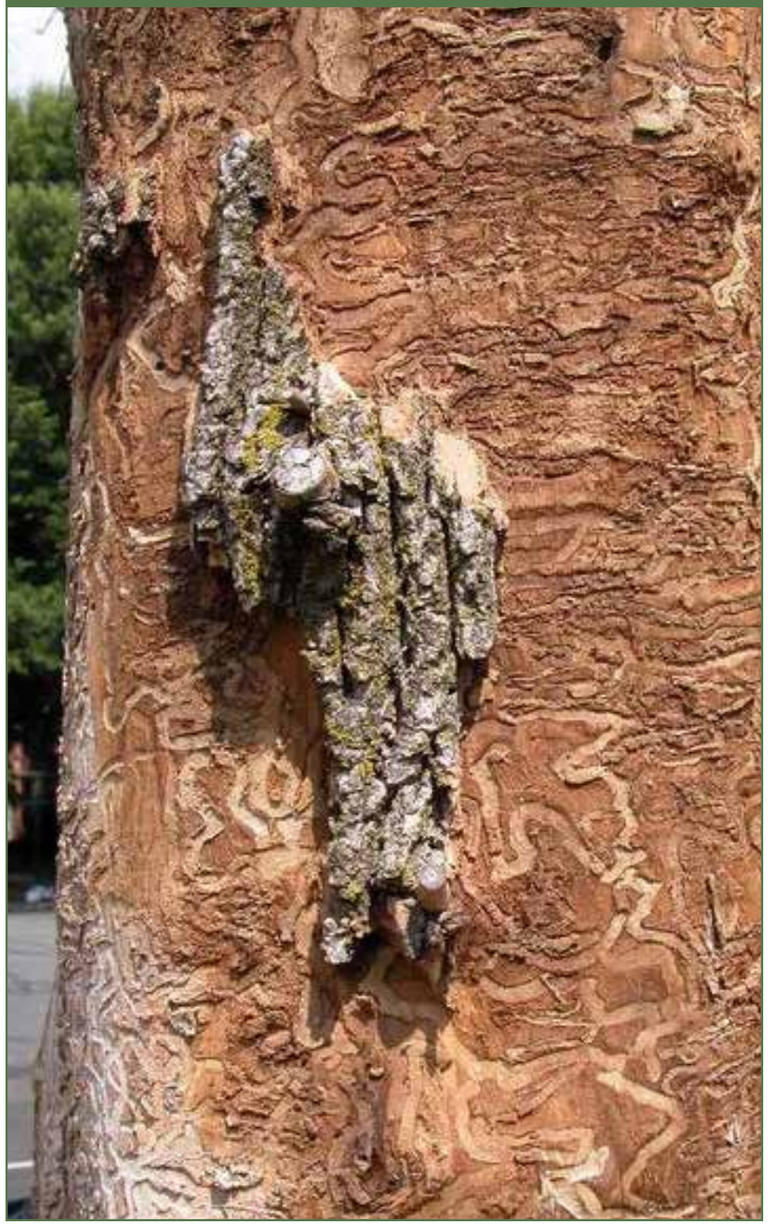
EAB was likely introduced in Boulder through infested firewood around 2008. In late September 2013, Boulder Forestry staff discovered an EAB infestation within the city. The beetles were detected by staff when sampling a dead ash tree prior to its removal. This was the first detection of EAB in Colorado and to date, the western-most occurrence of this invasive pest in North America. A subsequent inter-agency survey showed EAB was well-established within Boulder at the time of discovery.

Forestry staff and local arborists have been treating larger diameter (>9” DBH), healthy ash with pesticides as one defense against EAB. This prophylactic approach will reduce the impact of EAB in individual trees where the treatment is applied. EAB is 100 percent deadly to ash trees that are left untreated.

Bark removed by woodpeckers searching for emerald ash borer larvae and pupae.

Currently, ash trees comprise 12 percent of Boulder’s public trees and this percentage is estimated to be the same for private property. Over the next five years, EAB is expected to reduce Boulder’s urban tree canopy by approximately 25 percent (776 acres), reducing the overall canopy cover from 16 percent to 11 percent. The impact of EAB will have considerable economic, social, and environmental impacts for decades. To date, the cost of EAB management, including tree removal, tree replacement, wood disposal, and pesticide treatments has already impacted the Forestry budget and diverted resources from routine, necessary operations.

Distinctive “S” shaped curves indicate that EAB larva have fed on the interior of the tree.



"D" shaped holes are formed when the adult EAB beetles exit the the branches and trunk of the tree.

Forestry staff sampling an ash tree with EAB symptoms.

EAB Impact

In terms of invasive forest pests, EAB may well represent the worst-case scenario. EAB management differs from other invasive tree pest management strategies in five major ways:

1. Mortality of susceptible hosts: There is very little resistance to EAB in North American ash species. Researchers have found almost 100 percent mortality in most species of ash and especially green ash, which is the prevalent ash species across Colorado. EAB also kills ash trees quickly; at high EAB populations, EAB can kill mature trees in one to two years.
2. Scope of infestation: There are more trees susceptible to EAB than any other invasive pest to date. DED in Colorado killed approximately 30,000 American elm trees over a 40-year period and threatened 200 million elms across the U.S. EAB threatens 1.45 million ash trees in the metro Denver area alone and threatens an estimated 7.5 billion ash trees across the U.S.
3. Difficulty in detection: Evidence indicates EAB is typically established in an area for three to eight years before discovery. Since beetles attack in the upper canopies first; at low populations, trees often do not show symptoms until several years after initial infestation. There is no available pheromone for trapping purposes and EAB symptoms are similar to those of other insect pests and environmental problems.
4. Speed of infestation within community: EAB populations expand exponentially. Mated female beetles produce 40-70 eggs on average but can produce more than 200 eggs. Populations can therefore expand quickly before detection. Midwest cities report that without the use of pesticides, all ash within a community are dying after just ten to twelve years from introduction.
5. Public safety risk: Ash trees killed by EAB dry out and start to fail within a year of mortality, posing a risk to public safety and becoming costlier to remove, as arborists must use special equipment and techniques when stability is compromised.

Ash is one of the most abundant tree species in Colorado comprising approximately 15 percent of all deciduous trees in many urban areas. At the time of detection approximately 12 percent of Boulder's public trees were ash. Assuming a similar percent of private trees, the estimated number of public, private and naturalized ash in Boulder is more than 70,000 trees.

Emerald Ash Borer Life Cycle

Egg

0.4 inches in diameter. Creamy white egg that turns to amber. Eggs are laid from mid-June and well into August. Females deposit their eggs individually on ash trees, between layers of outer bark, and in the cracks and crevices of the trunk and major branches. Eggs hatch in about two weeks.

7 - 10 Days

Larvae

1 to 1.25 inches in length. The new larvae tunnel through the bark to the cambial region and feed on phloem. Phloem is a thin layer of tissue beneath the outer bark that conducts sugars and other nutrients throughout the tree. Without the ability to transport sugars and nutrients, the tree dies.

1 Year

Pupae

0.25 to 0.6 inches in length. During April and May of the next year, the overwintering mature larvae will pupate inside their pupation cells and gradually transform into adults.

1 Month

Adult

0.25 to 0.6 inches in length. Long, metallic, emerald green bodies. After one to two weeks, these new adults chew D-shaped exit holes in the bark and emerge from the ash trees. Adult emergence starts in late May and peaks in June. Adults must feed on ash leaves to mature. They start mating after about one week and laying eggs in three weeks.

1 - 3 Weeks

Development & Growth

In many communities across the U.S., land development threatens urban tree canopy, especially when parcels include high-quality established trees. Another challenge to tree preservation is site management on construction projects. Tree preservation of private mature trees, although a priority for city staff is not necessarily a priority for private developers. As a result, long-term survival for these trees is often not attained. When trees of appropriate species are found in good health and condition, developers are encouraged to retain them. It's Important to recognize that significant barriers exist, including:

- Young trees on development sites are improperly placed;
- There is a lack of specialized care for young, newly planted trees;
- There are requirements for ongoing maintenance to ensure private trees reach a mature size and structure, but there are enforcement challenge;
- Irrigation systems are not maintained;
- Dead trees are not replaced; and
- Regulations require planting but not maintenance; if trees die in the first year, there is no follow-up.

Conclusion

The City of Boulder is well aware of the importance of trees and urban forests to the health and sustainability of the community. Boulder Forestry staff exhibit a high level of expertise and dedication to managing the community's urban forest assets and they are supported in their education and professional development.

Boulder Forestry has assembled a strong foundation for managing urban forest resources and operations. Forestry staff use a robust asset management system to track the condition and history of every public tree, plan work, conduct threat analysis, and develop informed management strategies. A GIS-based land cover map provides information about the location and extent of existing canopy and a platform for development of a comprehensive planting plan. A current resource analysis details the structure, condition, value, and environmental and socio-economic services provided by the public tree resource. This information provides a basis for long-term planning and establishes benchmarks for measuring the success of management strategies.

Boulder Forestry is recognized nationally for demonstrating leadership and best management practices. The existing forestry program is very progressive, with a diverse range and depth of services, including annual tree inspections, tree risk evaluations, maintenance and safety pruning, integrated pest management, and community outreach. It is important to note that many of the highly-skilled leadership positions within Boulder Forestry are nearing retirement, thus planning for employee growth and development is a high priority.

The planning process for the UFSP revealed few inefficiencies in Boulder's urban forestry program and those that were identified are generally beyond the control of staff, including budget shortfalls and external threats from severe weather and invasive pests.

EAB, severe weather, and climate change are important considerations when planning for a healthy and resilient urban forest. Mortality estimates for the combined assumptions of standard tree mortality and mortality from pests is a 25 percent reduction in canopy within the next decade if proactive measures are not taken. A comprehensive tree planting initiative to meet the community's goal of no-net-loss of tree canopy is a high priority for the UFSP. Ongoing adaptive management and monitoring success are cornerstones to building an even more resilient urban forest for future generations. Increasing species diversity and protecting existing healthy trees are crucial to preserving Boulder's urban forest and the contribution of trees and canopy to quality of life and sustainability of the community.

Industry BMPs recommend routine tree pruning be conducted every five to seven years. Since 2012, due to safety pruning and removals necessitated by unusual weather events, pest invasions, and increasing costs for contact services, the routine pruning cycle has increased to 11 years for park trees and 15 years for public street trees. This has created a backlog of deferred maintenance and an increased number of annual service requests from the public. Deferred maintenance is far more critical than simply responding to more service requests. More than 67 percent (13,034) of young trees

(<6” DBH) are medium and large-maturing trees that still have a lot of growing to do before they reach maturity. Structural pruning is critical at this stage to prevent costly issues and branch failures as these young trees mature into their final size in the landscape. Deferring maintenance affects the health and safety of trees, results in additional failures during severe weather events, reduces the lifespan of trees, and increases risk to people and property.

In the past, staff were conducting safety inspections on approximately 100 trees per year. Due to the advanced age and size of trees in older neighborhoods, that number is now 200 to 250 trees per year. This presents another challenge concerning evaluation and monitoring, especially for the TSIP and newly established trees. Risk of trees in the TSIP are currently much lower than trees 20 years ago because the highest risk trees were already removed. The scope of the program represents a significant logistical burden on Forestry operations and may need to be scaled back to keep up with demand.

The City of Boulder has a proven track record of interagency collaboration, as demonstrated by the interdepartmental EAB response. Two key challenges exist for coordination and collaboration efforts among Boulder departments. The first challenge is clarifying the expectations of workgroup roles and department jurisdictions when facing an emergency response event. There are multiple workgroups within and between departments who play a key role in emergency response protocols and decision making. Furthermore, the characteristics of an emergency event will differ dramatically and will sometimes change which group takes on the role between these varying emergency scenarios. While there are a few emergency plans in place, disaggregating which workgroup does what throughout all potential emergency scenarios that Boulder might face will continue to be an ongoing challenge. It is important to continue collaborating with departments to define and plan for varying emergency events that will impact the urban canopy. This is especially true with Public Works, as this has been identified as a critical department to work with in the face of emergency response planning.

The second challenge is synchronizing software and database management tools to be congruent. Currently, there are several different tools employed among different teams which increase technological miscommunication. Beehive has received positive feedback from the stakeholders who use the software.

Community outreach and public perception are high priorities for Boulder Forestry. Nationally-lauded workshops and presentations, combined with an informative and easy to navigate website, provide the community with educational opportunities.

In recent years, cost of living increases, mounting public expectation for service delivery, and stagnant organizational budgets have created some gaps between public expectations and service capacity. Emerging urban forest threats, changes in climate, and community growth are obstacles to maintaining the high level of service expected by Boulder residents. In many cases, challenges can be viewed as opportunities for development and increased efficiency.

To provide the recommended level of care for the community's urban forest resources, Boulder Forestry will require additional funding. Specifically, current funding levels are inadequate to support:

- Pruning and maintenance cycles: The industry recommendation is five to seven-year rotation;
- EAB management: The costs for treatment and removal will continue to rise over the next several years;
- Traffic control and towing costs are increasing: for some trees, the traffic control costs exceed the removal cost;
- A tree planting initiative to preserve Boulder’s current level of tree canopy cover (16%): The initiative requires increasing public tree planting to 600 trees per year and facilitating 2,025 new trees on private property;
- Planting initiatives should include an increased level of young tree care because proper watering and structural pruning are required to ensure young trees live to their fullest; and
- Public engagement and programming.

What Do We Want?

Community Input

Outreach for the UFSP focused on two stakeholder groups; managing stakeholders (those who plan for, maintain, or manage the public urban forest) and the community at large. Each of these groups is a crucial partner in a successful urban forestry program. Every stakeholder has unique goals and insight that contributed to the development and priorities of the UFSP. Two Forks Collective coordinated with Boulder and DRG to develop a phased outreach process to determine the community's views about current needs, trends and attitudes about urban forestry programs as

Branching Out
Our Trees. Our Legacy.

	2013	2014	2015	2016	2017	2018
	PHASE ONE Background Research and Analysis	PHASE TWO Technical Needs Assessment and Analysis of Information and Goal Establishment		PHASE THREE Action Plan -Recommendations, Priorities and Implementation Strategies		PHASE FOUR Draft and Final Plan Development and Consideration by Parks & Recreation Board
PLAN PROCESS	Emerald Ash Borer (EAB) Long Term Strategy - Detection Efforts - Emergency Response - Interdepartmental EAB Strategic Group Initial Tree Canopy Data Collected	Public Tree Inventory Documented - All Public Park and Street Trees Inventoried - Inventory Data attached to Asset Management Software All Public Tree Maintenance Tracked	Urban Forest Resource Analyzed - Structural Characteristics Collected - Baseline Data Derived Advisory Boards Updated	Urban Forest Strategic Plan Kicked-Off - Consultants Selected - Technical Advisory Team Identified - Public Engagement Plan Developed	Urban Tree Canopy Assessed - Overall Canopy Cover Calculated - Canopy Potential Determined - Forest Fragmentation Identified - Carbon Storage Calculated - Annual Benefits Calculated - Priority Planting Sites Identified Advisory Boards Updated - City Council Updated - Community Working Group - Consulted	DRAFT Urban Forest Strategic Plan Reviewed Remaining to be accomplished in 2018: - *Final Urban Forest Strategic Plan to be Developed* - *Advisory Boards to be Updated* - *Presented to Parks and Recreation Board for Consideration of Approval* - *City Council Presented with Information Packet*
COMMUNITY ENGAGEMENT	What did we do... • Surveys..over 300 responses • Interviews with stakeholders, forestry experts and city officials • Tree Story Stations...over 100 submissions • Open House...approx. 200 attendees • Working Group Session- three sessions over 8 months • Youth Opportunities Advisory Board Presentation • Growing Up Boulder – Youth Engagement Who did we hear from.... • Residents • Neighborhood Associations • Commercial and business organizations • Education community • Non-profit organizations • Environmental organizations • Government organizations			Tree Stories Collected Stakeholders Interviewed - Internal - External Surveys Taken - Technical - Public	Public Open House Community Working Group (3 meetings) Youth Water Festival Tree Give Away with National Arbor Day Foundation Volunteer Tree Plantings	Public Open House Remaining to be accomplished in 2018: - *PLAY Boulder Foundation's Tree Trust Initiative Kick-off Event* - *Tree Give Away with National Arbor Day Foundation* - *Youth Water Festival* - *Volunteer Tree Plantings* - *Discounted Tree Sale*

well as assist in the development of relationships that will support the long-term stewardship of Boulder's urban forest. The public engagement process included qualitative and quantitative methods for outreach and engagement, including:

- Stakeholder Long Form Survey
- Community Short Form Survey
- Tree Story Stations
- Tree Speak Public Open House (2)
- Working Group Meetings (3)
- Feedback from the Youth Opportunities Advisory Board (YOAB)
- Interviews with stakeholders, forestry experts and city officials

The following is a summary of the public input received on key issues for Boulder's urban forest and the forestry program. A full accounting is available in the Community Input Report (2017) developed by Two Forks Collective.

Surveys

Long-Form Survey

For the long-form survey, the consultant team and Boulder Forestry identified key stakeholder groups that were important to get feedback from on current forestry issues. These groups included representatives from local businesses, neighborhood associations, local arborists, youth and community groups, non-profits, and education. The survey was sent out via email from Boulder Forestry to key contacts from these stakeholder groups after an initial phone call to describe the project. The email included a brief description of the project and a link to the survey. All responses were anonymous, though participants were given the option to include contact information if they were interested in being contacted further about the project. The survey was conducted in the fall of 2016 and resulted in sixty-two responses total. While the survey is not a randomized sample, and therefore generalizations about the responses are limited, the use of validated questions in larger community surveys allows for comparisons of these responses to the general population.

The survey asked a combination of questions to better understand stakeholder's beliefs, values, knowledge and attitudes about the urban forest, Boulder Forestry and their activities, their views about their community, the environment, current issues in urban forestry, and demographic information. The survey also included questions on current environmental behavior and their willingness to engage in tree stewardship. The survey used a combination of multiple-choice, open-ended, and validated measures from other Boulder surveys to allow for comparison.

The long-form survey had five main goals:

1. To understand what stakeholders think and feel about the urban forest in Boulder.
2. To understand what stakeholders know, think, and feel about Boulder Forestry's activities, responsibilities, and goals.
3. To determine what groups are the most or least concerned about issues around the urban forest, including attitudes and values.
4. To determine if knowledge of Boulder Forestry's activities is influenced by certain variables, such as demographics, residency, and values.
5. To understand stakeholder willingness to engage in tree stewardship activities, and which factors may influence this willingness, including identifying groups most and least willing to engage in tree stewardship.

Short-Form Survey

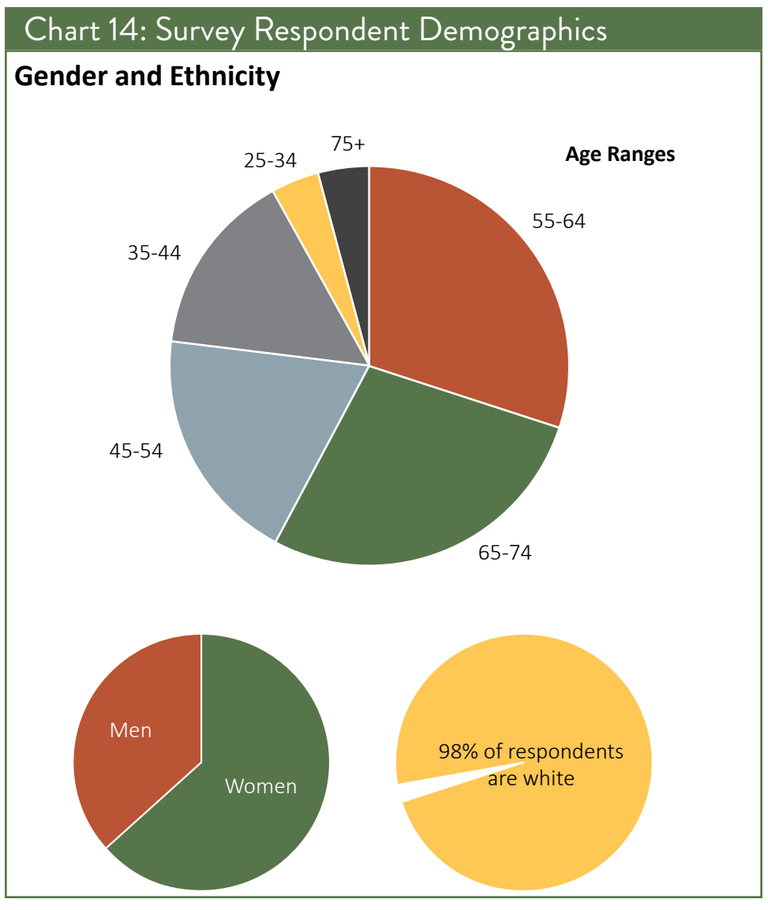
As Boulder Forestry expressed the desire for the survey to reach a larger selection of residents, a short version of the survey was developed that only included questions on residents' attitudes and knowledge about Boulder's urban forest, Boulder Forestry activities, and their willingness to engage in tree stewardship. No demographic, current environmental activities, or current attitudes and level of engagement in city issues were included. The goal of the survey was to get a general snapshot of attitudes and values around these questions from a slightly larger sample, but without identifying which groups to target in order to reduce the length of the survey and increase the response rate. The short-form survey resulted in 290 responses.

This survey analysis looks at findings from the five goals of the long-form stakeholder survey to help inform the development of the UFSP, findings from the short-form survey and how they compare to the long-form survey, initial themes that emerged from the tree storytelling workshops held in the fall of 2016, and themes from the Davey key informant surveys and interviews. This report also compares the findings from the surveys to larger, statistically-significant surveys conducted

recently in Boulder: the 2014 Boulder Community Survey, the 2015 BVCP Community Survey and Focus Group Summary Results, and the 2014 Boulder Parks and Recreation Department Master Plan. Lastly, this report offers recommendations for who to target, and how, for marketing and outreach for the UFSP and tree stewardship.

Survey Results

Chart 14: Survey Respondent Demographics



Who answered the long-form survey? How does this compare to Boulder's population?

Organization

For those who answered (43/62), 42 percent came from a neighborhood association, 23 percent from a commercial or business organization, 21 percent from the education community, and 9 percent from a non-profit/environmental organization. Only 2 percent answered the survey from government.

Age

For those who answered (49/62), over 50 percent of the respondents were over 50.The high level of responses for older respondents may also be a reflection of more time available for community involvement, especially as over one third of the respondents were from a neighborhood organization, and is typical in community outreach efforts.

Education

For those who answered (48/62), respondents were evenly divided into thirds between having a bachelor, masters, or doctoral degree, with slightly more having a bachelor's degree.

Residency

Given research that has linked residency to increased likelihood of community involvement and attachment, the long-form survey also asked respondents about their residency. For those who answered (50/62), 92 percent of respondents were residents of Boulder, and over 50 percent (62%) have lived in Boulder for over 20 years. Being a resident of Boulder from between 2-20 years was evenly divided around 12-14 percent. The vast majority of respondents also owned their residence (88%). For those who answered (48/62), 50 percent did not have children living at home, which is not surprising given the older age of the majority of respondents, while roughly a quarter had children aged 12 or younger or adults over 65 living with them. When compared to Boulder's population, this sample has a slightly longer residency rate (20 years or more versus an average of 17 years), and a higher rate of home ownership (88% versus the 53% in the BVCP). The household composition of the respondents roughly correlates with Boulder's household composition, with roughly a quarter of respondents having either children under 12 or seniors (over 65) living with them (BVCP).

Contacted further

Lastly, just under half of the respondents (48%) were willing to be contacted further to participate in a focus group.

1. What stakeholders think and feel about the urban forest in Boulder (questions 1-7).

Urban Forest: Definition

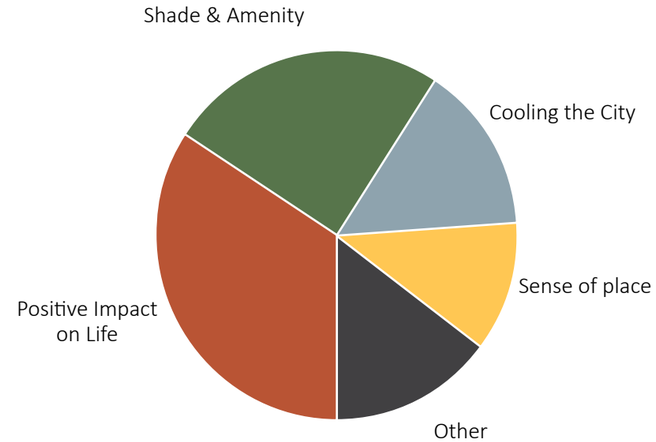
When asked about what they defined as the urban forest, almost 60 percent of survey respondents felt that it included all trees and woody shrubs in the city, with 20 percent defining it as street and park trees. This is encouraging in terms of stakeholders understanding that trees are part of a larger ecosystem, and is reflected in almost 70 percent perceiving an association between the urban forest and open space. However, it also reflects public confusion about Boulder Forestry responsibilities and tools to address tree health on public and private property. As only street and park trees are considered

part of the community urban forest in Boulder (and under it's jurisdiction), this presents an opportunity for Boulder Forestry to clarify roles and responsibilities with the public, as well as use this general concern as a starting point for tree stewardship.

Urban forest: Associations and Values

Respondents were also asked to identify up to three words to describe Boulder's urban forest. By far the most common response was centered on beauty, with serene/relaxing, dynamic/vital, shade, quality of life, maintenance and threatened, nature, diverse, health and love following as primary themes. Secondary themes include references to the seasons, open space,

Chart 15: Survey Respondent Associations and Values



81% Associating the urban forest with their neighborhood quality

70% Have a good sense of community

66% Informed themselves on Boulder's issues

and the threat of development, which is not surprising given the priority of the preservation of Open Space seen in the 2015 BVCP. Respondents were also asked if they associated Boulder's urban forest with the nature surrounding Boulder. This is important since research shows that urbanites do not always associate urban nature with 'nature', and thus value it's preservation and creation less than 'nature out there'. The majority of respondents associated Boulder's urban forest with surrounding nature and open space (76%). While the association between urban nature and bigger 'outside, untouched' nature is not always positive-i.e. urban nature is considered 'weak' nature- (Hough, 2004), previous surveys in Boulder have indicated that there is a strong identification with and values around environmental stewardship and the preservation of Open Space (BVCP and parks MP) among Boulder residents (City of Boulder and County, 2015). Furthermore, in the 2014 Boulder Community Survey nearly all the respondents reported visiting both Open Space and neighborhood parks (City of Boulder, 2014), which traditionally is indicative of a higher personal valuation of these spaces. In addition,

Boulder residents have prioritized a unique identity and sense of place and this has been linked to the quality of both Open Space and neighborhood and public spaces (City of Boulder Parks and Recreation, 2014). As trees have traditionally been associated with a high level of symbolism and personal attachment (versus grasses for example) (Pearce, Davison, and Kirkpatrick, 2015), this may explain why they are highly valued and associated with larger nature outside the city.

A majority of respondents also somewhat or strongly associated Boulder's urban forest with climate change

(44% and 41%). This association again shows that for these respondents they recognize, at some level, the link between Boulder's urban forest and larger environmental issues. This also reflects one of the 2015 Boulder Valley Comprehensive Plans' key values, which is environmental stewardship and action on climate change.

Urban Forest: Benefits

Neighborhood quality is also linked to neighborhood attachment and residential satisfaction. These are important since neighborhood attachment has been linked to environmental behavior such as recycling, and therefore potentially tree stewardship (Takahashi and Selfa, 2015).

Urban Forest: Threats

Almost 80 percent of respondents felt that pests and disease were a threat to Boulder's urban forest. This likely reflects recent efforts by Boulder Forestry to educate Boulder residents about the threat of pests and disease, and in particular EAB, to the urban forest. However, only 51 percent of respondents felt that climate change was threat to the urban forest, closely followed by lack of maintenance (44%).

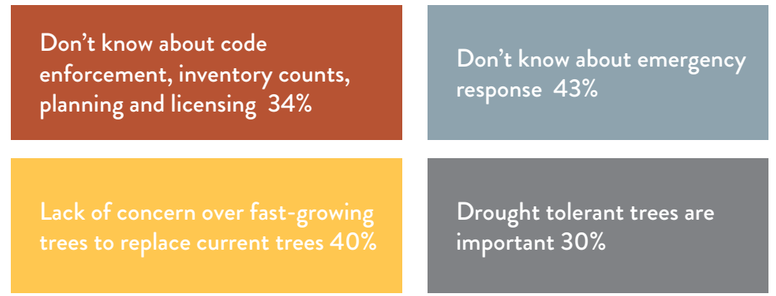
This question also included an 'other' category. For the long-form survey, 50 percent of respondents indicated that development and construction was a threat to Boulder's urban forest, with maintenance, Boulder Forestry and Boulder's government also mentioned as primary themes. Secondary themes included a lack of awareness of the interconnectedness of ecosystem services and benefits, pests, pollution, and sprawl/ increasing population.

Urban Forest and Larger Boulder Policy

Respondents' ambiguity about the impact of climate change on the urban forest is reflected in respondents' ambiguity on whether current Boulder policy documents on climate change, resiliency, and comprehensive planning had any relationship to the urban forest. While most respondents felt there was some association between the urban forest and the BVCP, with 75 percent feeling that they were or somewhat related, almost equal numbers did or did not see any relationship between the urban forest and the climate change plan (32% and 37% respectively). However, Boulder Forestry messaging about climate change seems to have gotten through to a higher percentage of their listserv respondents than the short survey with almost 80 percent of the short form respondents associating Boulder's urban forest with Boulder's climate change plan. The resiliency plan was also more associated with the urban forest, with 68 percent perceiving some relationship, but a sizable percentage (31%) did not see any relationship. This ambiguity speaks to the need, also identified by Boulder Forestry staff, for better coordination and collaboration between Boulder departments on initiatives and messaging around the role of the urban forest. This should be helped if Boulder Forestry receives more sustainable funding and in-house expertise to help them deal with current and upcoming forestry issues.

2. What stakeholders know, think and feel about Boulder Forestry activities, goals, and responsibilities (questions 8-15).

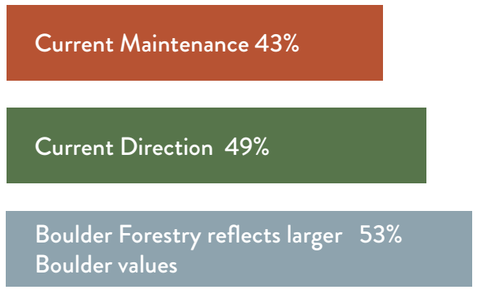
Most respondents were somewhat familiar or had heard of most of Boulder Forestry's responsibilities. Given the wide variety of respondent knowledge about Boulder Forestry responsibilities it may help to have a more targeted message about key roles that Boulder Forestry deems essential for Boulder residents to know about and that support the UFSP. Similarly, there was a wide variety in responses about what the top goals of Boulder Forestry should be, possibly reflecting a lack of knowledge about what is needed for the health of the urban forest. This might reflect a lack of awareness or understanding about the scale and timing of the threats to the urban forest as indicated by forestry staff, as well as increased frustration with current maintenance of the urban forest.



This question also included an open-ended response option for both surveys. Respondents indicated that education, maintenance, and pests were key responsibilities they thought Boulder Forestry should be responsible for, with some unsure about current responsibilities or adequacy of services. Secondary themes included clarifying homeowner versus Boulder Forestry responsibilities, issues around drought and tree watering, inventorying and increasing bushes and shrubs along street frontage and in parks, and uncertainty or dissatisfaction with current levels of maintenance and outsourcing.

Satisfaction with current Boulder Forestry Activities

While there is room for improvement, this also speaks to an opportunity for Boulder Forestry to focus on targeted, clear goals and messaging, public engagement, and alignment with larger Boulder goals and values more explicitly through the UFSP process and marketing. It also means that current opposition may be from a vocal minority, not the larger population (at least from this sample). Similarly, when educated (in the phrasing of the question) with the reasoning behind the removal of trees, the vast majority did not like it but understood that it was sometimes necessary (95%). This is also seen in the respondent's feelings about insecticide use; given the introduction about why it is sometimes necessary in the survey question, 80 percent were okay with it if necessary. This speaks to the importance of messaging and education for Boulder Forestry, and the potential for insecticide use to be more acceptable with education.



Tree Stewardship

This is promising in terms of the goals of Boulder Forestry to increase public tree stewardship as part of the UFSP and to deal with threats to the urban forest.

50% / 61%
Interested in being a tree steward
~ Long / Short survey

Most were interested in moderate maintenance (50%), with 34 percent not interested or only interested in one-off help such as tree planting. While the short-form survey had a slightly higher percentage that was interested in tree stewardship, this is not surprising given the assumed higher level of interest and engagement with Boulder Forestry activities for their listserv. Also not surprising is a higher percentage of the long-form survey respondents who felt that Boulder Forestry should be responsible for maintenance. With further targeted outreach and messaging Boulder Forestry may be able to either increase the percentage of residents interested in tree stewardship or actively engage those interested in future programs.

3. Which groups are the most or least concerned about issues around the urban forest, including attitudes and values (questions 5-7).

Understanding what factors may predict concern over urban forestry in respondents can be important in order to tailor messaging and marketing for the UFSP. For question 5, which asked about respondents' association between Boulder's urban forest and surrounding nature and open space, respondents who had lived in Boulder for a long time, as well as those who felt at home in their community, were more likely to associate the urban forest with larger nature. Trees themselves, even street trees, are also often associated with strong emotional and personal connections for residents. This is supported by the associations with the urban forest and open comments from the survey addressed above, as well as the Tree Story outreach.

Given that the majority of respondents indicated that they were concerned about urban forestry and associated it with larger environmental issues, an analysis was also undertaken to determine if there were any characteristics that could be identified for those who did not identify urban forestry as important. In other words, is there a single variable or characteristic to explain their lack of interest, and how could this be used in outreach strategies? For question 5, there was no single variable that could explain respondents' lack of concern for the urban forest.

Similarly, there was no single variable that could explain respondents' who did not associate Boulder's urban forest with climate change, nor those who did not associate it with their neighborhood quality. As there was a fairly small percentage who did not show concern for Boulder's urban forest (as framed through these questions), this may help to explain the lack of a single variable or characteristic to identify these respondents. A larger sample, or a more representative sample (especially for traditionally under-represented survey groups, such as low-income, non-white, and younger demographics), may yield different results. However, the association of residential attachment with concern for urban forestry discussed above can help with marketing and outreach in terms of associating, through values and imagery, urban trees with place making and home, attachment and quality of life. This last quality in particular may be useful as it has been highlighted as a key value for Boulder in the 2014 Boulder Valley Comprehensive Plan.

4. Is respondents' knowledge and feelings about Boulder Forestry's activities influenced by certain variables or characteristics?

Another way of asking if Boulder residents are concerned with the urban forest is to determine how much they know and feel about Boulder Forestry activities, since a lack of interest would correlate with a lack of action

or initiative to find out more about Boulder Forestry activities. It is also helpful to know which groups are more likely to know about, and feel good about, Boulder Forestry activities in order to identify populations that might be 'low hanging fruit' to start with for outreach and marketing for the UFSP.

Statistical analysis synopsis

To do this, a model comparison approach was used to identify key indicators for respondents' knowledge and feelings about Boulder Forestry and their activities. First, a single response variable was created by averaging responses to two questions: Q8, 'How familiar are you with the Boulder Forestry responsibilities below?', and Q11C, how well respondents agreed or disagreed with 'Boulder Forestry's policies reflect the values of the Boulder Community' to create a single new metric called 'Knowledge.' All possible explanatory variables were then defined, including the demographic battery from the end of the survey, as well as other values and attitudes around the urban forest.

Linear regression models were created to assess the results. A model was created for every combination of six or fewer variables. This resulted in more than 35,000 potential models. Each model was then ranked based on its performance and complexity. If any two models had the same performance, the one with fewer explanatory variables was deemed preferable. This ranking was quantified using Akaike's information criterion (AIC).

Results

The resulting best-fit model had only two explanatory variables; 'TimeRecycled' and 'FocusGroup', which correspond to Q17A and Q30. Additionally, all of the top-performing models contain these to explanatory variables, and in every model these two indicators have the strongest explanatory effect. When examined more closely, both of these predictors have a significant positive relationship with the variable Knowledge. In other words, the more times per year a person recycles, the more likely they are to be knowledgeable and agree with Boulder Forestry activities. Similarly, those willing to participate in a focus group about urban forest issues are more likely to be knowledgeable and agree with Boulder Forestry activities. This is supported by research that shows that current environmental behavior is associated with a higher level of knowledge about environmental issues (Stern, 2000) and pro-environmental values (Liuna, Jingke, Lijuan, Wenjun, and Kexin, 2015). Given the high rate of recycling in Boulder, this may be a good place to start in terms of targeted marketing outreach.

5. Which factors influence a person's willingness and degree of participation in a potential tree stewardship program?

The last analysis focused on identifying what factors may influence a person's willingness, and degree of participation, in a potential tree stewardship program. This goal was identified in collaboration with Boulder Forestry given current budgetary constraints, the backlog of maintenance, and upcoming increased maintenance with climate change and pests. While the program is still under discussion and has not been developed yet, understanding respondent's willingness to potentially participate, as well as who might be the most willing, can be very helpful in marketing and outreach efforts.

Statistical Analysis Synopsis

For this analysis two questions were asked: 1) What factors indicate a willingness to participate in a potential tree stewardship program Q14, and 2) To what degree would respondents be willing to participate (i.e. level of tree stewardship) Q15. For both questions a similar approach was used as for the above analysis.

For Q14, the explanatory variables included the demographic variables, the new knowledge metric, and questions 3, 7, and 11, which asked about threats to the urban forest, associations between the urban forest and neighborhood quality, and feelings about Boulder Forestry's current activities. These explanatory variables were included given their insight into respondents' feelings about how much threat Boulder's urban forest is under (and therefore Because of the increased number of variables the number of combinations that could be explored was reduced, which created a logistic regression model for all combinations of five or fewer explanatory variables. This resulted in over 16,000 models.

For Q15, the same approach was taken, with the same explanatory variables. Because responses to Q15 have multiple levels, a multinomial logistic regression was used. Again, a regression was compared for every combination of five or fewer explanatory variables, producing 16,000 models.

Results

For Q14, the results show that the key variables associated with their level of interest in participating in

a tree stewardship program are a) Time spent gardening (either at home or in the community), b) Education, and c) Time spent in Boulder (residency). Specifically, those with a bachelor or master's degree, who have lived in Boulder 2-5 years, or 16 plus years, and those who engaged in gardening activities, were more likely to interested in participating in tree stewardship. It is unclear why those who have lived in Boulder between 11-15 years were not as likely, but this could be due to time crunches, age, and other factors, or just the sample for this survey. While due to a large standard error for each estimate no one variable can be assumed to be significantly indicative of participating in a tree stewardship program, the best models all contained these explanatory variables. This means that it is highly likely that outreach and marketing for residents who engage in gardening activities (and are thus more likely to be comfortable taking care of trees and other plants), who have a moderate level of education, and who are residents of Boulder will be more effective. It is also likely that these variables are linked, but the current data is too messy to determine their relationship.

For Q15, explanatory variables were added to the model and ranked on its probability that it explains respondents' level of participation to the question. These levels of participation are: 1) No response; 2) None of them. This is the responsibility of Boulder Forestry and should be covered by current taxes; 3) I would like to help out but am unable/it's not feasible to do so; 4) I would be willing to occasionally water a tree outside my business/residence/workplace; 5) I would be willing to water and maintain a tree outside my business/residence/workplace; 6) I would participate in tree planting; 7) I would participate in youth education.

The most likely response is to not participate (2), which indicates a bit of an uphill battle to get residents to participate in a tree stewardship program. However, comments from the 'other' response category in the long-form survey shed some light on this reluctance. Many indicated that age and health issues are a barrier to increased participation, as well as time limitations and a lack of specific information on specific trees. This is not surprising given the older age of this sample population, but can also be expected from residents aged 30-45 who are more likely to be in the crunch years of working and raising children. However, since the tree stewardship program does not exist yes, and would likely include more specific information on tree watering and responsibilities, this may increase potential willingness to participate. There were also comments about trees in the right of way; some were already watering the tree on their right of way since they deemed Boulder Forestry maintenance inadequate, which may reduce their desire to increase their participation, and many indicated a desire for a more comprehensive and clearer stewardship and enforcement program between property owners, managers, and the city. As confusion over responsibility for trees in the right of way are known to Boulder Forestry as on-going issues, it would be helpful for this to be part of the outreach and marketing for the UFSP. Comments over the desire to see a comprehensive, public, and integrated tree inventory and maintenance program online further support the need for integrated outreach and education.

For those willing to engage in some level of tree stewardship, the results show that the best models all identify a) participating in a focus group, b) the knowledge variable developed above, and c) Feeling at home (Q18) as key explanatory variables. This is not surprising given that those who are more willing to educate themselves about Boulder Forestry activities, who agree with them, and who are willing to participate in a focus group, are more likely to 'help out' through tree stewardship. Similarly, Feeling at home, which is linked to attachment to one's community, has been linked to an increased likelihood of environment action (Takahashi and Selfa, 2015). Given the priority in the 2015 BVCP over quality of life and sense of place, as well as links above between trees and neighborhood quality, it would be prudent to link Boulder Forestry activities to supporting and enhancing the quality and sense of place for residents' neighborhoods as one aspect of the marketing and outreach campaign. This is particularly true given the emotional and personal connection many residents expressed to trees in the Tree Story outreach and comments in the survey.

Tree Stories

At the same time the long and short form surveys were underway a broader outreach activity was taking place in a more creative form. In an effort to get the community thinking about "trees", we developed "Tree Story Stations." A series of wood boards were created

and temporarily placed in the Main Library, recreation centers and at local events. People were given information about the development of the Strategic Plan and asked to submit stories, photos, drawings or poems on-site or online, illustrating their connection to trees. As an added incentive each submission would automatically enroll you in a monthly drawing for a variety of prizes from Boulder Parks and Recreation.

Over 100 submissions were shared at the stations and online by a wide range of community members including children. The submissions were very moving and reflected how deeply connected the Boulder community is to trees. A selection of stories were also shared in a special display at the public meeting for other community members to enjoy.

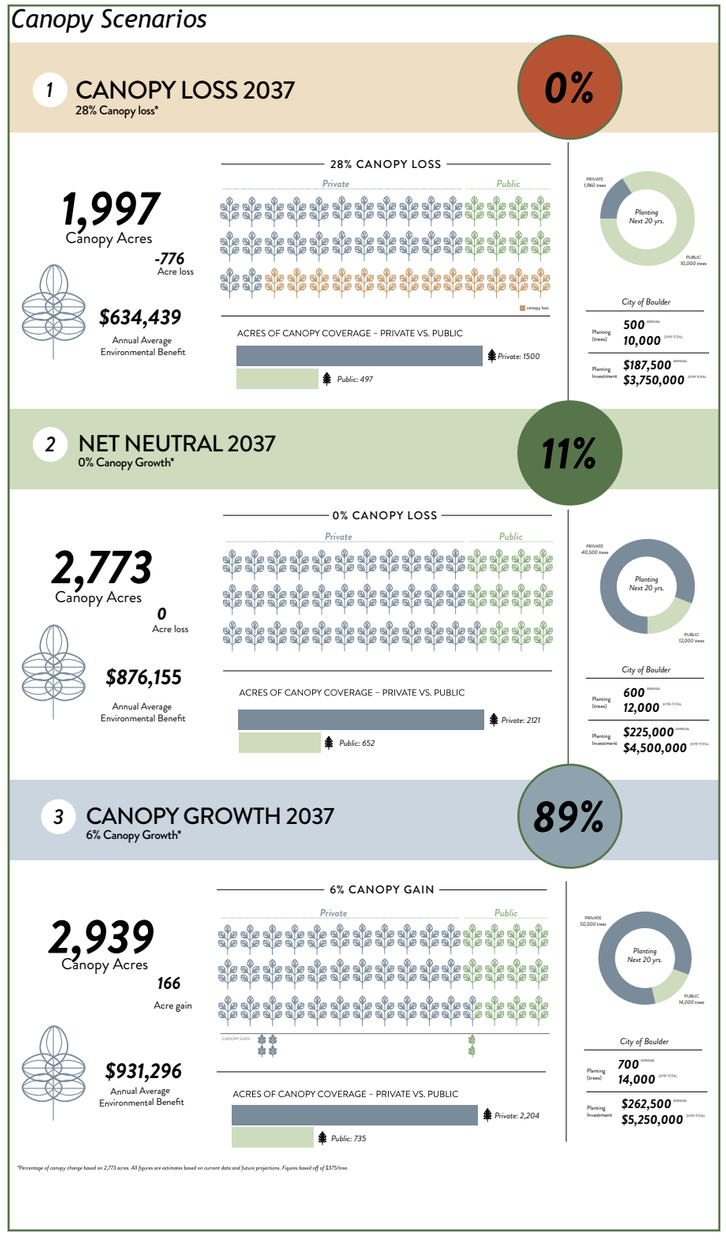
Tree Speak Open House

The initial public meeting hosted at a local public gathering space, was designed to provide the community an opportunity to learn about the role of Boulder's Forestry Division, an overview of the strategic plan process, summary of the initial analysis and bring awareness to the vast number of programs and resources forestry provides. In addition the event hoped to capture the community's response to recommendations on maintaining and growing Boulder's urban canopy and what types of outreach activities that would be most effective.

Multiple stations featuring specific topics allowed attendees to either learn individually or engage with members of the forestry division. Two stations sought to capture the community's preference on maintaining or growing the urban canopy over the next 30 years,

providing options on how to achieve proposed canopy goals. There were also individual stations devoted to EAB Awareness, the TreeOpp program, Tree Story submissions and a demonstration on interactive mapping tools.

The event was well attended, with a wide variety of participants. Approximately 130 people RSVP'd to the event, however it was estimated that close to 200 people attended.



Station Responses

Canopy Scenarios

Participants were given a graphic overview of Boulder's current urban canopy along with information on current threats and their impact on the canopy over the next 20 years. Community members were then presented with three scenarios and the requirements to achieve each outcome presented. Community members presented their preference for a scenario by voting with a sticker. The three scenarios presented were canopy loss, net neutral-no loss in canopy, and net gain-a small growth in canopy over the next 20 years. 89 percent of those who voted preferred canopy growth over the other two options.

The community was then asked to provide their preference on a list of tactics that would help achieve a net neutral or net canopy gain. Below are the community preferences for the tactics outlined.

How do we take care of it?

1. **Tree Planting Requirements for Private Projects 21% -** Increase the minimum requirements for tree planting and on-going care for private development or re-development projects.
2. **Tree Planting for Public Property 15.6% -** The city should plant additional trees on public lands, in parks and on street rights-of-way.
3. **Subsidized Tree Planting for Private Property 14.5% -** The city should host a program to help subsidize the cost of tree planting on private property. This could include passing on bulk pricing for trees and/or support in planting trees.
4. **Tree Planting Requirements for City Projects 14% -** Increase the minimum requirements for tree planting on city development or re-development projects.
5. **Increased Tree Protection Standards for Private Projects 12.6% -** Tree protection standards exist for public trees. Add defined requirements for acceptable tree removals and tree protection during construction for private property trees on private development projects.
6. **Create a Foundation 11% -** The community should create a foundation to solicit private/corporate funding to supplement tree planting, maintenance and/or education.
7. **Mitigation Funding for Tree Removal 6% -** Mitigation is required by code for public trees removed on any development project. Add a requirement for trees removed on private property for development projects. Funding could be ear-marked to support community tree planting projects.
8. **Increased Tree Protection Standards for City Projects 5% -** City development or re-development projects should have defined requirements for acceptable tree removals and increased tree protection standards during construction.
9. **Other Ideas (comments):**

- More diversity in tree species
- Full time staff devoted to planting and young tree care and maintenance
- CSU Master Arborist Program (similar to Master Gardeners (plus 3 votes)
- Outreach volunteers to help homeowners plant and care for trees (plus 3 votes)
- More budget money for Forestry
- Plant more female trees to reduce woes of allergy sufferers. Worth it for diversity.
- Don't let developers remove trees

Working Groups

Working Group 1

In an effort to collect more in depth insights from the community and initiate relationships for long-term stewardship, Boulder Forestry and the consultant teams, identified eight key stakeholders to participate in a series of working group sessions. These individuals included a representative from a local nursery, practicing certified arborists, neighborhood association members, a member from a local tree related non-profit, and a member of Boulder Community Hospital. The working group participants attended two facilitated discussion sessions.

The first working group session was designed to familiarize working group participants of Boulder Forestry activities and work to date regarding Boulder's public trees. This was followed by a presentation of the baseline urban tree canopy analysis for Boulder, canopy over the next 20 years including EAB and other invasive pests, climate change, severe weather events and development.

> *"We need to communicate how long it takes to properly replace canopy in addition to the loss that is inevitable, and how taking care of trees can help maintain the canopy."*
>
> *~Working Group Participant*

The group was then presented with three scenarios that take into consideration the gap in existing resources for maintaining canopy given known threats.

- Scenario 1: a 28 percent canopy loss by 2037
- Scenario 2: Net Neutral Canopy by 2037
- Scenario 3: 6 percent canopy growth by 2037.

Working group participants reviewed the scenarios and provided feedback on how they thought the community would react to impending canopy loss and what their preference would be regarding the three scenarios presented. All working group participants agreed that establishing a goal to grow the urban canopy was optimal.

The discussion followed three basic themes:

- Messaging: Improve the city's messaging regarding our current canopy, strongly emphasizing impending threats and their overall impact over the next 20 years.
- Awareness: Education on the importance of trees should be presented in the context of tree's impact on human health.
- Additional Information: Provide detailed information to the community on the maintenance costs associated with each canopy scenario and how this fits within the city's priorities and budget.

The working group was then asked to provide their thoughts around community wide solutions to preserve Boulder's urban tree canopy. Below are the opportunities the working group identified.

- Using the Boulder Arts community as a model, the community needs to present to the city their desire for an additional tax that can be applied toward efforts to preserve and grow Boulder's tree canopy.
- Identify effective tree related non-profits and emulate their tactics.
- Have the city emphasize the gap that exists between what is needed to maintain and grow Boulder's urban canopy and what can be accomplished with the existing budget.

Working Group 2

In the course of reviewing the feedback from the initial working group session, comparisons were made to other communities with experience implementing desired programs and strategies. Davey Resource Group reviewed over 25 different programs considered to be successful urban forest strategies. Working group participants were provided these real-world examples of successful programs across the following topics: volunteer engagement, resilience and sustainability; tree planting initiatives, city-non-profit partnership and tree protection. In the second session the working group was divided into three smaller groups and given one of the following topics and questions to focus on:

> *"Trees are directly associated to human health. Clean air is one of the most valued resources. Messaging should be focused around health, (trees are) critical for the health of our children, creating a healthy environment for our children. It is critical for human life for trees to exist in our community."*
>
> *~Working Group Participant*

Volunteer Engagement

- How does this get started and who should be responsible for management and funding?
- What type of program would be most effective in Boulder?
- Tree Planting Initiatives
- What challenges and opportunities do you see for engaging residents and encouraging tree planting (and care) on private property?
- Should taxpayers subsidize or facilitate tree planting and care for private property? How?

Tree Planting Initiatives:

- What challenges and opportunities do you see for engaging residents and encouraging tree planting (and care) on private property?

- Should taxpayers subsidize or facilitate tree planting and care for private property? How?

Tree Protection on Private Property

- Do you support some level of tree preservation requirement for private property?
- Would you support a tree removal permit process separate from the development process?
- Should mitigation (in lieu of preservation) for private tree removals be allowed?

The outcomes of these smaller focused discussions echoed may of the recommendations from the first session while identifying some key components that were seen as necessary for success. Below is a summary of key findings for each topic covered.

Volunteer Engagement:

- Focus on the issue of EAB and other critical threats to the urban forest to provide a "call to action" in the community.
- Clearly and effectively communicate the consequences of EAB and its impact on the forest.
- Encourage community participation through volunteerism, promotions, fundraising, and partnership.
- Focus on more "close to home" initiatives such as working with neighborhood groups, schools, churches or commercial centers manage and care for their trees through planting, pruning, treating, etc.
- Consider innovative and effective marketing strategies such as leaving dead trees in place temporarily, illustrating future view corridors without Ash, etc.

Tree Planting Initiatives:

- The working group recommended that an advocacy group outside of city staff needs to champion an initiative to educate, inspire, mentor and train community members on planting initiatives, protecting and caring for trees on private property and how to ensure sustainability of the urban forest.
- An advocacy group should also consider funding programs and incentives for tree protection, planting and maintenance in the form of grants, discounted nurseries, or consider tax initiatives to fund forest initiatives similar to other designated taxes for resource conservation.
- Trees are a critical component of public health, economic vitality and livability in a community. They should be prioritized and funded similar to any other critical infrastructure especially with the resiliency and sustainability in mind.
- Also consider a long term approach through changes to development codes to increase planting or preservation and care of existing trees on private property.
- Consider an attractive and effective marketing campaign to increase public awareness through social media, professional groups, youth engagement and digital interactive tools that allow the community to interact with forest management.
- Work collaboratively with all other sustainability and resiliency initiatives that focuses on climate action, conservation and livable communities.

Tree Protection on Private Property:

- The working group supports the idea of exploring tree protection on private property and recognizes that many communities along the Front Range currently have some form of this within the city.
- The group understands that tree canopy goals can't be met just from planting, we need to effectively manage and protect existing trees.
- Need to initiate a systematic methodology for exploring an option for this in Boulder that is based on science, criteria and evaluation metrics.
- Could start small with a pilot program and work towards a comprehensive approach that would result in smart regs, incentives instead of penalties.
- Need rigorous engagement and buy-in from community with an understanding that the urban canopy doesn't see property lines and is a community resource.

Working group participants agreed to continue to be part of Boulder's Urban Forest Strategic Plan process by reviewing the draft plan providing feedback and recommendations on the strategies outlined.

Working Group 3

For the third working group exercise, participants were provided in advance, a draft version of the Urban Forest Strategic Plan (UFSP) along with a summary of community outreach efforts to date and a document outlining UFSP Goals, Priorities and Actions derived from all of the data and community input gathered thus far. The session was designed to focus on 7 goals where the working group would have the most impact. Below are the seven goals in no particular order or ranking.

1. Establish a no-net-loss urban tree canopy (UTC) goal through 2037
2. Create an Urban Forest Emergency Response and Drought Plan including overall citywide coordination and clean-up efforts.
3. Updates to city codes and policies to better protect public and private trees to achieve the UTC goal.
4. Establish and increase funding and staff resources to support all Forestry maintenance operations to desired community level of service for urban forest management.
5. Explore the establishment of a partner non-profit urban forest foundation or "tree trust" to leverage additional financial and community support for the urban forest.
6. Develop a community-led volunteer program focused on urban tree canopy.
7. Continue existing and develop additional youth engagement programs including educational presentations, school tree plantings, opportunities for input, etc.

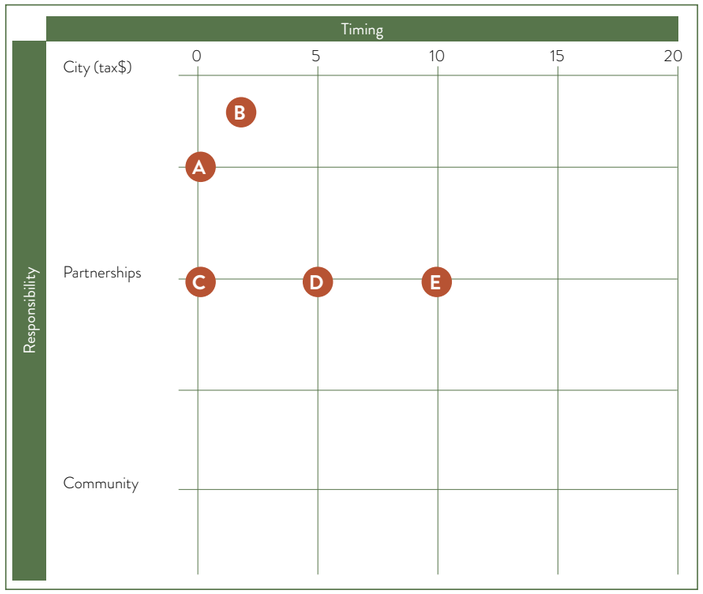
Each overarching goal had 3-4 specific actions. The working group was asked to discuss the actions presented, prioritize them in order of importance, specify where these actions fell on a timeline between 1-20 years, and designate the level of responsibility between the city, strategic partnerships and the community. The groups collective decisions for each action were then charted on separate maps.

Q1: Establish a no-net-loss urban tree canopy (UTC) goal through 2037.

ACTIONS:

- **A** Communicate the goal to the community and engage them in identifying and executing solutions.
- **B** Develop and implement a Public Tree Planting Plan to achieve the UTC goal. The plan should have both citywide and neighborhoods specific planting and diversification targets to increase street tree stocking with a diverse mix of well adapted species.
- **C** Educate private property owners on diversification goals needed for large maturing trees and proper tree maintenance to ensure trees live to maturity.
- **D** Incentivize, educate and partner with private property owners to provide cost sharing, free replacement trees or incentives to contribute to planning efforts on private property.
- **E** Asses canopy cover for progress and adjust planting and/or preservation goals as needed-recommended time frame: every 10 years.

Some key comments that came out of the discussion for goal no. 1 include:



- There is an opportunity for contractors and commercial arborists to help educate the general public on species diversity and the city's proposed goals. As well as providing educational support around tree maintenance and care for both young and mature trees and how this directly plays into achieving the citywide preference of no-net-loss UTC.
- Marketing and communication: Benefit of communication, possibly hiring professional firm.
- Communicating the same message- work with partner groups to get message out.
- Initiate a Tree Keepers organization to help

with maintenance and promptly recognizing and recording harmful pests.

- Partner with a non-profit organization that can provide the educational programing needed through a stable volunteer base.
- It is vital to have educated neighborhoods to help generate buy-in and participation in helping to achieve the stated UTC goal.
- Focus funds on educating the community rather than providing free replacement trees. Free trees don't always establish a strong foundation for continued care and maintenance.
- Examine possible incentives for rental property owners to help maintain and care for trees on their properties.

Goal 2. Create an Urban Forest Emergency Response and Drought Plan including overall citywide coordination and clean-up efforts.

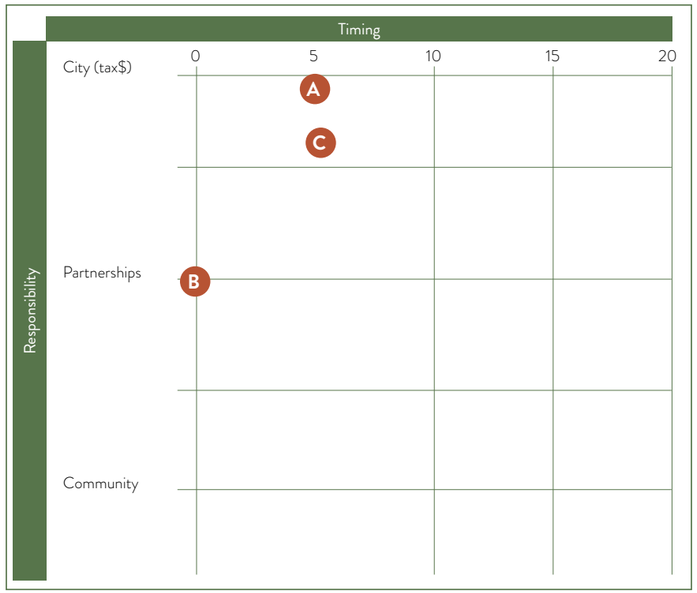
ACTIONS:

A Develop an Urban Forest Emergency Response Plan including overall citywide coordination with clear role clarification among departments and criteria for different levels of pruning and citywide cleanup efforts.

B Educate property owners about trees and drought so they can be prepared and know what to expect when water restrictions are enacted.

C Coordinate with Utilities Division to develop a Parks Drought Plan that establishes priorities and appropriate amount and timing of irrigation per tree species per park site based upon science and research based horticultural Best Management Practices.

Some key comments that came out of the discussion for goal no. 2 include:



- Bring back 'Spring Clean-Up Day'- a former citywide effort
- Ensure that tree maintenance education is shared across all existing vehicles of communication (email/newsletters/social media).
- Look at Fort Collins Emergency Response Protocol as an example to emulate.
- Educate and communicate is a resonate need in the plan, there needs to be "someone" whose job it is to do this. The city should exploit every city opportunity to communicate need to water and tree maintenance- it will affect everyone.

Goal 3: Updates to city codes and policies to better protect and maintain public and private trees to achieve the UTC goal.

ACTIONS:

A Revise licensing requirements for Certified Arborists performing tree work in Boulder (may include shift from existing two-tier to single Certified Arborist License, require proof of safety training, educate all licenses on pertinent city codes, develop enforcement mechanism to ensure company compliance with all licensing requirements, etc.).

B Start community dialog on appropriate updates pertaining to trees on Public Property:

i. Develop Park Design and Construction Standards, update Tree Protection (for public street trees), Diversity and Streetscaping requirements in the City Design and Construction Standards and ensure consistency.

ii. Develop pesticide application permitting system for private treatment of street trees similar to City of Denver requirements. Ensure industry best management practices are followed for the maintenance of all public and diseased trees. Update code to address enforcement and penalties

iii. Review current ordinance and policies for public tree protection and strengthen where appropriate.

iv. Enforce existing requirements for irrigation and mulching for public street trees by adjacent property owners.

v. Prioritize the upgrade of streetscaping along arterials to allow for trees long term through Capital Improvement programs including installation of permanent irrigation systems (example locations include 30th St, Iris Ave., and Foothills Pkwy).

vi. Create green infrastructure master planning document to improve stormwater management

vii. Review policies and enforcement for slacklining pilot project utilizing trees in city parks.

C Start community dialog on appropriate updates pertaining to trees on Private Property:

i. Convene a group of stakeholders to develop regulations for any new requirements for tree protection for private property trees. Determine what level of protection is desired by the people of Boulder.

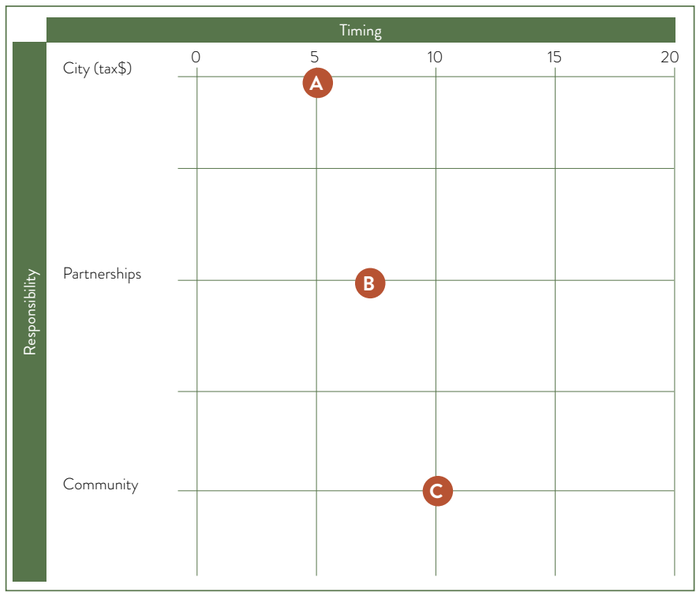
ii. Benchmark codes from other communities (i.e. prevent the removal of existing trees prior to acquiring an approved landscape plan, tree removal permitting process, preservation requirements for certain private property trees, require mitigation for significant, desirable private trees removed through development projects when replacements cannot be planted on site, mitigation requirements, etc.)

iii. Review and strengthen parking lot shade guidelines and enforcement.

iv. Update codes to add appeals process for enforcement of tree nuisance abatement on private property and lengthen the time frame for remedy to timeframe appropriate for tree and site conditions.

v. Update codes to improve and enforce long-term maintenance of landscape requirements on private property including provisions for inspection and enforcement. Add personnel necessary to oversee and monitor tree protection in construction on public property.

Some key comments that came out of the discussion for goal no. 3 include:



- These actions would require a 2-year public engagement process similar to the process that occurred under the Boulder Zero Waste Plan.
- This could fall under a 2018 citywide ecosystem management plan.
- Would it make sense for the Boulder Forestry division to reside under Resilience /Sustainability rather than Parks and Recreation?
- Other cities become accredited Tree Care Industry Association- These associations perform an audit every 3 years.

Goal 4. Streamline all forestry maintenance operations and establish and increase funding and staff resources to support desired community level of service for urban forest management.

ACTIONS:

A Strengthen and streamline Forestry operations maintenance processes and programs (includes outreach, pruning, IPM, tree risk, commercial trees, wood utilization, asset management, contracted services and continued implementation of the EAB Long Term Strategy.

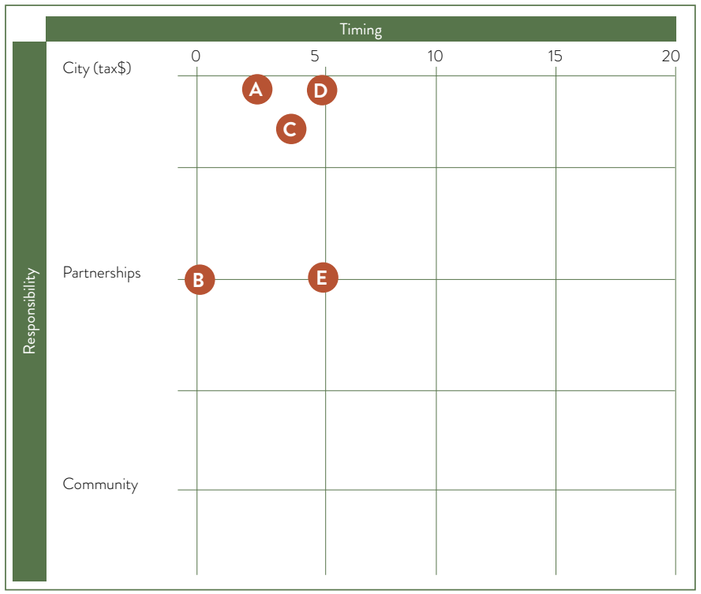
B Establish a sustainable funding mechanism for Boulder Forestry programs, including tree planting and rotational pruning.

C Engage executive management in discussion and collaboration regarding available/potential funding options that support the community vision for the urban forest and the desired level of service expressed by stakeholders and community members.

D Bank mitigation fees for private trees removed through site review projects (trees that cannot be replaced on site must be mitigated with funds going into the Tree Fund).Use funds to support new tree

planting, establishment, and maintenance, including programs that increase trees on private property.

Some key comments that came out of the discussion for goal no. 4 include:



- Citizens every two years have a funding requests- we should be asking residents to fund certain forestry efforts.
- Cultural Landscape Rehabilitation Funding could be source to help with tree planting and maintenance.
- Engage everyone, create lobby mechanism to get message out and get it on ballot.
- Organize all “public trees” into common management and establish funding mechanism
- A ballot initiative should be established to help fund Action B. This is illustrated on the graph as Action E.

Goal 5. Explore the establishment of a partner non-profit urban forest foundation or “tree trust” to leverage additional financial and community support for the urban forest.

ACTIONS:

A Create a call to action to articulate “Why Now?”

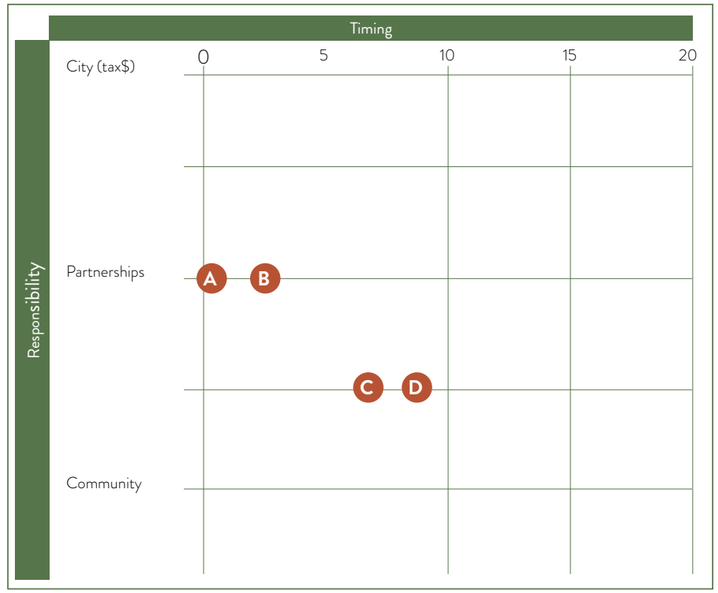
B Facilitate the development of a leadership team to direct the vision and capacity building of an emerging nonprofit. Tap into existing networks, resources, and populations (non-profits, businesses, NPO’s, government agencies, school districts, neighborhood associations).

C Develop specific and actionable goals and funding sources. The city can initiate a program with seed money and deliverables, but other fund-raising efforts will be necessary to support continued volunteer efforts. Explore grants for project funding and to diversify funding sources and partners.

D Evaluate outreach strategies and divide outreach between Boulder Forestry and urban forest foundation regarding raised money, trees planted and new memberships.

E Partner with private property owners to provide cost-sharing, free replacement trees, or incentives for private property tree planting. Note: This option was not reflected on the graph, as the working group participants couldn’t determine where this action should be located and how this effort may be executed.

Some key comments that came out of the discussion for goal no. 5 include:



- We need to identify potential benefactors to kick off a larger foundation.
- Corporate sponsorship.
- Create a tree trust committee to evaluate the establishment of a foundation.
- PLAY Boulder Foundation (PLAY) wants to take on the main arm of the foundation as the Tree Trust.

The feedback collected from these three working group sessions has helped to reevaluate and prioritize the actions for specific goals for the UFSP. Additionally this information will be used to help inform recommendations for a marketing strategy, identifying strategic partners, tactics and communication strategies.

Goal 6. Develop a community-led volunteer program focused on urban tree canopy.

ACTIONS:

- A Build a team of engaged advocates that understand the community's unique urban forestry challenges and opportunities.
- B Build a strong individual member base. Emulate tactics from other local organizations that are successful in advocating volunteers.
- C Develop volunteer-led programs and train volunteers to lead or assist with programs (may include: forestry maintenance and general support such as clearance pruning, pest surveys and reporting, mulch distribution, managing online requests, youth engagement/educational programs, educating community, host a program to help subsidize the cost of tree planting on private property, offering block grants to subsidize private plantings and assist neighborhoods in tree planting efforts, development of an urban forest newsletter, etc.)

Goal 7. Continue existing and develop additional youth engagement programs including educational presentations, school tree plantings, opportunities for input, etc.

ACTIONS:

- A Continue partnership with Utilities to educate youth about trees through city Water Festival.
- B Collaborate with Boulder Valley School District (BVSD) to develop urban forestry educational program for elementary aged children and present annually.
- C Continue seedling giveaway to Boulder Valley School District 5th graders.
- D Develop additional youth engagement programs.

The working group ran out of time before being able to reflect their decisions for Q.6 and Q7 on the graph presented.

Some key comments that came out of the discussion for goal no. 6 and no. 7 include:

- Infilling Arborist careers, Arborists are recognized as a skilled profession and therefore qualifies for workforce development initiative- Front Range apprenticeship program is currently being designed to create a pipeline teaching horticulture as career.
- Having the City of Boulder partner with local schools to help educate kids and create ambassadors.
- BVSD could partner with a non-profit for educational programing.
- Need to start educating kids at an earlier age
- All about collaboration with all stakeholders. Cooperative effort.
  Who coordinates?
- Tree Museum- at CU-an existing resource that could be utilized
  for education.

In conclusion, the recurring themes that have emerged from all three of the working group discussions include; clear effective communication regarding the importance of the urban forest and its' effect on each individual community members. The need for community participation, and that the community's desire for a level of service and urban forest management they are willing to allocate additional resources to.

Actions that identified the need for communication and education were given immediate priority and were seen as ongoing. This is evidenced in the charts for goals 1, 2 and 5 where all actions that include communicate and/or educate resided on the timeline between 0-5 years. Communication related actions were also prioritized as mainly the responsibility of the city and included the recommendation of hiring an outside marketing firm to craft an effective and engaging message.

From the working group perspective education related actions were seen as something that would be most effectively executed by strategic partners. This is consistent with past working group sessions in that it focuses on cooperation with community partners, sensing that strategic partners would likely be more effective in soliciting community participation, through their approach, ability to access various types of funding and resources. In addition the group emphasized that the urban forest is comprised of more than just public trees, it is a community asset, and therefore, the community envisions the need for a non-profit partner, urban forest foundation or tree trust to help cultivate and steer community involvement. During the final meeting it was shared that Boulder PLAY would like to become the foundation arm for a Tree Trust. Members of the working group recommended that a committee be established to provide some foundational framework for a Tree Trust to successfully take hold.

ADDITIONAL THOUGHTS TO CONSIDER:

- Professional communication and marketing
- Care is more consequential than planting
- Tree give-away care supplement. e.g. 10 min education pamphlet.
- Someone needs to be in charge of the education and communication.
- Reexamine spring clean up for tree maintenance.
- Should Forestry be under Sustainability or Resilience? ex. Recycling and Compost.
- Forestry is a citywide resource more than Boulder Parks and Rec or Public Works.
- Support accreditation of private companies.
- Bond funding to support Forestry/EAB.
- Cultural landscape rehabilitation funding for historic properties.
- Identify benefactors or corporate sponsors.
- Create a committee to direct the Tree Trust.
- Tree Trust vs. tree trust (general term.)
- Clarify tree fund in no. 4.
- Arboretum
- Include career development and training for youth (Youth Engagement).
- Start earlier than 5th grade, eco-cycle partnership for education.
- Champion tree list, highlight in the plan.

Overall, the greatest amount of discussion in each working group session continually focused on actions that closely align with the goals and actions stated in the 'Engage' section of UFSP Goals. This tells us that the community is in agreement with the UFSP stated need for the community to work alongside the department in order to achieve goals outlined in the strategic plan.

YOAB

In an effort to encourage Boulder's youth to become more civically engaged, Boulder has established a Youth Opportunities Advisory Board (YOAB). YOAB is a group of 16 City of Boulder resident high school students, who work to promote the youth voice in the community, provide opportunities for youth across the city and advise the municipal government on youth-related policies and issues. In addition to monthly meetings, each year students are involved in an Alternative Team Project, (ATP). ATP's are semester-long projects comprised of 3-4 students who select their own topics based on the opportunities available and what is meaningful to them.

Boulder Forestry coordinated with YOAB to present the Boulder Urban Forestry's Strategic Plan process in an effort to see if the students identified an element of the plan they felt their peers would be interested in as a topic for their 2017 Fall ATP.

John Marlin, a member of the Boulder Forestry division, gave an overview of the plan, the role of Boulder Forestry and impact of pests such as the emerald ash borer. As a whole students were most interested in the large loss of canopy due to emerald ash borer and how they could be part of the solution. With this topic in mind the group split into 4 smaller groups to discuss specific ideas on what a future ATP project would entail. As a result a semester long project will be co-developed with the students, allowing them to take their creative ideas and help educate the public around threats to Boulder's Urban canopy.

Young Children's Tree Preferences

Boulder Forestry coordinated with Growing Up Boulder, Boulder Journey School, and Boulder County Head Start in an effort to collect insights and generate awareness among young children. Growing Up Boulder is Boulder's child-and youth-friendly city initiative and is based out of the Community Engagement Design and Research Center at the University of Colorado Boulder; its mission is to empower Boulder's young people with opportunities for inclusion, influence, and deliberation on local issues that affect their lives.

Through a series of activities that included outdoor exploration, discussion video and drawing, children were able to express their preferences and expand their understanding of trees in their natural environment.

The following summarizes young children's thoughts about trees.

- Provide shade.
- Have berries, seed pods, and acorns to squish and use for imaginative play.
- Encourage wildlife (squirrels and chipmunks).
- Are deciduous, so they can play in the leaves.
- Bear fruit, because they can eat the fruit and climb these trees more easily.

The results of these activities were communicated through a brief video and poster which was shared at the public meeting.

Final Open House

The final draft of Urban Forest Strategic Plan (UFSP) was presented to the Boulder community at Upslope Brewing Company. This meeting provided a chronology of the research, community outreach and milestones that occurred throughout the process. Additionally this meeting provided Boulder Forestry the opportunity to present a comprehensive summary of the strategic goals and actions that will take place in order to meet the needs of Boulder's urban forest as well as community stated desires for the future of their urban forest.

Multiple stations featuring specific topics allowed attendees to either learn individually or engage with members of the forestry division. The stations focused on sharing the goals and actions outlined within the UFSP, providing continued education around EAB, GIS mapping, data collection and introducing the partnership with the PLAY and their initiative of creating a Tree Trust. A core objective of the event was to clarify where city's Forestry's efforts will be concentrated and clearly communicate the level of community participation needed in order to achieve collective goals.

The Goals and Actions boards showed goals across four main categories: Plan, Protect, Manage and Engage. In response to one of the actions within the Engage category, Boulder forestry partnered with PLAY, one of the featured stations at the event. PLAY has been in the process of developing a Tree Trust, an initiative designed to help assist with educating and engaging community participation around Boulder's urban forest. Their station focused on introducing the Tree Trust initiative to the community, recruiting volunteers and gathering community preferences around priorities for the Tree Trust over the next few years.

PLAY solicited feedback on activities related to each UFSP goal category. Feedback from the community revealed an overall preference for activities under the categories of Protect and Manage. The specific activities that received the most interest were: Fund tree plantings and care program for private trees through a Tree Trust membership model, and Digital mapping of private

trees through a neighborhood/HOA mapping program. Community members also shared some of their own ideas, which included a summer camp for kids involving tree identification and care, educating neighborhoods on tree care and initiating friends of the urban forest.

The event was well attended and participants were very engaged and able to successfully field their questions with members of the forestry division. The station focused on GIS mapping tools had a number of participants interested in finding out more about their own trees. PLAY also had many lucrative conversations around the Tree Trust, receiving 6 volunteer requests, two of which committed to joining the Tree Trust committee and one interested in spearheading a Friends of the Tree Trust membership program focusing member retention at the neighborhood level.

Conclusion

We can conclude from the engagement process that the Boulder community values their urban forest, understands impending threats and wants to see the urban canopy thrive and grow.

We also know that the continued health and maintenance of Boulder's urban forest is a complex task that requires

joint efforts from the community and Boulder Forestry. Though this process members of the Boulder community have helped identify the core areas where assistance is needed:

- Clear concise messaging around the benefits and threats to Boulder's urban forest.
- Broader, ongoing community wide education focused on maintaining Boulder's urban forest.
- Community participation in activities that best support Boulder Forestry efforts.

The emerging partnership with PLAY is a strong first step that has the potential to help with education and community action. However, additional help will be needed to support a citywide communication effort that aligns with the strategic goals and actions outlined in the UFSP and also effectively align with efforts from strategic partners.

Davey Resource Group worked with Forestry to identify successful programs throughout the U.S. in order to explore best practices and potential solutions to address the challenges and opportunities identified

Case Studies

by Boulder stakeholders. We explored the structure and policies of more than 25 different programs and interviewed program leaders to better understand the key components that lead to success. DRG reviewed focused on nonprofit tree advocacy, volunteers, resiliency and sustainability, preservation, tree planting initiatives, food gardens, and solar solutions (Davey Resource Group, 2017). The case studies offer insight into strategies that were particularly effective, as well as possible pitfalls to avoid. Lessons learned from these programs were incorporated into the priorities and actions of the UFSP.

Conclusion

Plan Goals and Priorities

Based upon review of the current urban forestry program and resources,and input from the community and other stakeholders, the UFSP identifies four goals.

Plan

Urban forestry is an important part of Boulder's resilience strategy. Increasing the resilience and sustainability of the urban forest directly supports the resilience of the community. The priorities of this goal include; establishing a no-net-loss canopy goal, developing a planting initiative that increases trees on public and private property, increasing species diversity, development of specific resiliency plans (climate, emergency, drought, pests etc.), and integrating urban forestry goals with other city guiding documents.

Manage

Boulder has an exceptional Forestry program and already implements many industry BMPs. Management priorities for the UFSP explore; the consolidation of urban forestry responsibilities, increasing staff resources and funding, providing a more consistent contracting operating procedure, improvements to the tree inventory database, further development and integration of the IPM program, and periodic review and alignment of UFSP priorities.

Protect

The urban forest represents a valuable asset, one which must be nurtured and protected. This is accomplished through municipal code, policies, and design and construction standards that support tree planting and longevity. The priorities of this goal include; revision of tree protection codes and policies, improved standards for tree maintenance, expanding options for tree mitigation payback, streamlining pesticide permitting, and improvements to the TSIP.

Engage

The Boulder community places a high value on environmental stewardship. Engaging with and educating the community with the most current information on the urban forest will mobilize activists and facilitate policy implementation. In the development of the UFSP, many stakeholders expressed a desire for a community-based urban forest advocacy group to promote, protect, and enhance Boulder's urban forest. Priorities to engage the community are; communicating UFSP goals and plans, diversifying funding sources and partners, facilitating private property tree plantings and maintenance, and the establishment of a partner non-profit urban forest foundation.

How Do We Get There?

Goals, Priorities, Actions

The UFSP analysis provides a spatial understanding of the past, present, and future potential for tree canopy, and is a valuable tool to help managers align urban forestry management with the community's vision for Boulder's urban forest.

In Boulder, plantable areas include 4,335 acres, and within that area, 905 acres are high or very high priority planting areas. These high and very high priority planting areas offer the highest return on investment.

Given current losses to EAB and anticipated losses to continued climate change stressors, Boulder Forestry's overarching 20-year goal will be to restore and maintain, rather than increase, its current canopy cover of 16%.

Boulder Forestry will achieve this goal through smart planning, effective management, tree protection and community engagement. These four themes are explored in the following pages.

The strategic plan includes three cost scenarios, following the city's business planning approach that requires departments to prepare for a future without increased revenue. This approach acknowledges the need for an effective organization to balance priorities—and their associated expenditures—using three tiers of fiscal alternatives.

- The Fiscally Constrained ($) alternative plans for prioritized spending within existing funding.
- The Action ($$) alternative describes the additional services or capital improvement that could be undertaken when additional funding is available.
- The Vision ($$$) alternative represents the complete set of services and facilities desired by the community.

GOALS

Plan

PRIORITIES

- Develop and implement a 20-year Planting Plan for public trees to support the 16% urban tree canopy cover by 2037.
- Participate in an inter-departmental Urban Ecosystems Management Strategic planning process to integrate ecosystem protection and monitoring across urban, agricultural and wildland systems.
- Create an Urban Forest Emergency Response Plan for citywide coordination to ensure appropriate coverage and minimize risk to the public.

Manage

PRIORITIES

- Establish a dedicated, sustained funding source beyond the departmental budget for Boulder Forestry operations to increase the level of service to meet the community's high standards.
- Expand the Public Tree Planting program to support efforts toward the goal of 16% canopy by 2037.
- Shift management responsibility for all trees in public street ROW and around public buildings under Boulder Forestry to maximize advantages in expertise and scale.
- Increase investment in proactive, preventative maintenance by exploring options to increase the frequency of pruning events for public street trees.
- Refine the Integrated Pest Management (IPM) Program to improve tree health while minimizing cost and negative impacts to ecosystems and the public.
- Streamline the Tree Safety Inspection Program (TSIP) to manage risk and minimize City exposure to claims as well as reduce the financial and logistical costs on forestry operations.
- Continue implementation of the EAB response strategy to maintain public safety, ecosystem services, and forest function in the face of unprecedented canopy loss.
- Transition to a common software Asset Management System to allow efficient forestry business processes across city work groups and provide essential baseline data for strategic forest management.
- Continue to explore all wood utilization options to improve resiliency to increased cost or disappearance of any single waste stream.
- Explore the expansion of the Commercial Tree Program (CTP) beyond the immediate downtown area to maintain urban tree canopy, protect property and better manage public safety issues.
- Develop a staff succession plan within Forestry to encourage continual professional development and facilitate transitions in leadership to minimize disruption to operations.
- Deliver a State of the Urban Forest Report biennially for elected officials, key urban forest stakeholders, and the public.

Protect

PRIORITIES

- Strengthen Boulder Forestry's role in all city CIP projects to minimize damage to tree assets and canopy loss.
- Strengthen existing city requirements for trees on Public Property to increase tree protection, improve site preparation and strengthen tree species diversity requirements to maintain the urban tree canopy and increase forest resiliency.
- Strengthen existing and develop new city requirements for Private Property to increase tree protection, improve site preparation and strengthen tree species diversity requirements to maintain the urban tree canopy and increase forest resiliency.
- Revise licensing requirements for all tree care companies performing tree work in Boulder to improve public safety and tree health.

Engage

PRIORITIES

- Provide the community with balanced and objective information to assist them in understanding the problems, alternatives and options to achieve the Boulder urban tree canopy goal.
- Partner with the community on projects to broaden knowledge, support and funding for the Boulder urban tree canopy goal.
- Develop and expand opportunities for community involvement in the commitment to achieve the Urban Tree Canopy goal.
- Involve the public on the analysis, alternatives and recommendations for further urban forestry related planning processes and potential code changes.

PLAN

Urban forestry is an important part of Boulder's resilience strategy. Resilience is the ability of a community to prepare for and respond effectively to stress. Some stressors occur suddenly, like the 2013 flood, drought, and invasive pests. Others take their toll over time, including ever-increasing maintenance costs, ongoing development pressure, and the senescence of large specimen trees. Whatever the stressor, what is most important is that resilient communities not only bounce back from these challenges but also "bounce forward." These resilient communities preserve the quality of life today and improve their legacy for future generations. Boulder's urban forest serves as a buffer to many community stressors, providing cooling shade, cleaner air, and a reduction in stormwater runoff to avoid sudden and more severe flooding. Increasing the resilience of the urban forest directly supports the resilience of the community.

The following priorities and actions support this goal:

Timeframe	Cost	Priorities and Actions
Year 1-5	$$	**1. Develop and implement a 20-year Planting Plan for public trees to support the 16% urban tree canopy cover by 2037.** a. Outline achievable canopy cover goals by maintenance district, accounting for current canopy level, land use, soils, irrigation, vulnerability to heat islands and storm water, community desires and equity. b. Determine ideal percentages for species diversity at every scale from block, to maintenance district to citywide. c. Conduct urban tree canopy (UTC) analysis every ten (10) years to record changes and progress towards community canopy goals. d. Conduct tree resource analysis every ten (10) years to record changes and progress towards planting and diversification goals. e. Identify species that will be resilient to potentially drier, hotter conditions of Boulder's future climate. f. Identify baseline species diversity within maintenance districts, develop lists of desirable species for each maintenance district and establish diversification goals per maintenance district. Prioritize large stature shade trees to maximize leaf area and ecosystem service provision per tree. g. Establish a specific number of plantings for each year through 2037. Prioritize tree planting within neighborhoods based on canopy priorities. Focus tree planting where community need is greatest. h. Ensure tree planting and diversification goals are included and prioritized within all city projects. i. Future planting schedules will be adjusted to account for any season that falls short of its goal. j. Develop process to monitor survival of new plantings and modify planting schedule to account for losses. k. Develop process to comprehensively reassess canopy by maintenance district every ten years to determine if progress is proportional to goals. This evaluation process should include revisiting planting plans if the program is not on track to meet 2037 goals.

Timeframe	Cost	Priorities and Actions
Year 1-5	$	**2. Participate in an inter-departmental Urban Ecosystems Management Strategic planning process to integrate ecosystem protection and monitor across urban, agricultural and wildland systems.** a. Participate in a consortium of environmental planners, activists, researchers, and organizations to develop an integrated ecosystems management strategy that can address increasing environmental threats and build on opportunities to enhance ecosystems and ecosystem services in and around the city. b. **Collaborate on the Plan with staff from multiple departments such as OSMP, Long Range Planning, Public Works, Utilities, etc.**
Year 6-10	$$	**3. Create an Urban Forest Emergency Response Plan for citywide coordination to ensure appropriate coverage and minimize risk to the public.** a. The response plan should include branch clean-up efforts, wind/snow storms, floods, and planning for each stage of drought. b. Using data from the 2002 drought and other dry periods, prioritize trees within city parks based upon species, size, contribution to the site and overall value to the community to maintain adequate tree canopy. c. Determine which areas of park landscapes should be irrigated to preserve highest priority trees based on drought severity and duration and use appropriate amount and timing of irrigation for species preservation in line with water conservation goals. d. Keep watering regimes during drought conditions in mind when designing future park irrigation systems. e. Ensure adequate water for trees in median areas during periods of mild to moderate drought. f. Work with the Utilities Division to establish temporary modified water budgets for parks during periods of drought and when establishing new landscapes when original landscapes were impacted by natural hazard. g. Clarify roles of city personnel for coordination, communication, pruning/removal of public trees, and debris cleanup management in the event of wind or snow storms or other local natural disasters causing major damage to trees. h. Develop criteria for appropriate levels of city inclusion into branch clean-up efforts based upon storm impacts; criteria may include: Minor events - residents responsible for their own debris removal; Moderate events - limb drop-off services provided by the city; Major events – citywide clean-up.

MANAGE

Boulder has an exceptional Forestry program and already implements many industry BMPs, from selecting quality nursery stock, to regular maintenance and pruning, to the removal process when salvageable wood is utilized. Boulder's 50,800 public trees are maintained and inspected regularly, with their history and status tracked in a management database. Since 2013, the personnel, training, equipment, and budget to support these activities has not kept pace with community expectations, leading to longer pruning cycles, increasing response times, and some deferred maintenance. Reasons for this include the steeply increasing costs of contract pruning and traffic control plans and an unprecedented number of recent tree removals due to severe weather events and invasive pests, including the EAB.

These management priorities, goals, and tactics provide guidance for steering Boulder's advanced and proactive urban forest management program back in line with the community vision for the urban forest.

The following priorities and actions support this goal:

Timeframe	Cost	Priorities and Actions
Year 1-10	**$-$$$**	**1. Establish a dedicated, sustained funding source beyond the departmental budget for Boulder Forestry operations to increase the level of service to meet the community's high standards.** a. Engage executive management regarding potential funding options, such as voter-supported bonds to fund capital projects for improved infrastructure and streetscaping along arterials and improved future maintenance. b. Develop process to collect mitigation fees for private trees removed through development projects to increase tree planting and post-planting care. c. Identify the funding mechanism when new public trees are added through development. d. Research the ability to use urban forest planting and/or preservation projects to earn carbon credits and create an additional funding source. e. Allocate funding to temporarily increase the annual tree planting budget for ten years to support urban tree canopy goal. f. Anticipate budget changes due to living wage requirements for tree planting and maintenance contractors. g. Identify options for short-term funding to manage emergency response for tree damage after storm events, including debris management.

Timeframe	Cost	Priorities and Actions
Year 1-5	$$	**2. Expand the Public Tree Planting program to support efforts toward the goal of 16% canopy by 2037.** a. Develop a more strategic approach to species and site selection to ensure the resilience and optimize ecosystem service provision of Boulder's urban forest. b. Conduct a cost-benefit analysis of contracted versus In-house plantings to maximize available resources. c. Increase the number of trees planted on public property to support urban tree canopy goal. d. Coordinate with other city departments to maximize the number of trees planted through CIP projects. e. Collaborate with nurseries to propagate a more diverse palette of trees that tracks Boulder's diversity requirements and updated planting recommendations. Determine if nurseries may offer discounts for lower income families. f. Continue collaboration with regional urban forest managers to explore opportunities for cost-sharing and bulk pricing for tree stock and/or growing trees through multi-year contracts. g. Experiment with new tree species to assess their performance in Boulder's climate. Establish a pilot for different nursery stock to assess potential inclusion in procurement/planting processes. h. Develop a consistent methodology to monitor and track new planting survivability long-term. i. Formalize and document planting program business processes with a focus on entering new trees into inventory and assigning early growth stage maintenance at planting.
Year 6-10	$	**3. Shift management responsibility for all trees in public street ROW and around public buildings under Boulder Forestry to maximize advantages in expertise and scale.** a. Collaborate with other city work groups to document current public tree assets and jurisdictions. b. Calculate the cost maintaining existing trees outside of Boulder Forestry jurisdiction and identify potential funding sources for all maintenance. c. Initiate conversation between departments regarding consolidation of city owned trees under Boulder Forestry along with proportional resources. d. Collaborate with Public Works on protocol for clearance pruning, including training of Public Works staff and joint pruning operations. e. Collaborate with flood utilities to develop proactive tree removal plan for ash trees infested with EAB along creek flood ways.

Timeframe	Cost	Priorities and Actions
Year 1-5	$$-$$$	**4. Increase investment in proactive, preventative maintenance by exploring options to increase the frequency of pruning events for public street trees.** a. Maintain the current eight-year pruning rotation for city park trees to address structural defects in trees before time and growth make them costly and hazardous. b. Phase in the reduction of the systematic pruning rotation for street trees from the current 14 years to the industry recommended eight years while expanding the number of size classes pruned. Evaluate progress annually to ensure program is moving towards the eight-year goal. c. Estimate cost/benefit of expanding pruning rotation to include Flatirons Golf Course. d. Develop a process to standardize and assign follow-up work and structural prunes on young trees. e. Annually revisit contract specifications and in-house policies and directives to ensure that tree care operations adhere to current industry standards, including ANSI A300 Standards for Tree Care Operations, ANSI Z133.1-2012 for Arboricultural Operations Safety Requirements, and ISA Series BMPs. f. Ensure that all tree care operations comply with federal and state wildlife protection requirements. Forests in natural areas should be managed as minimally as possible to preserve wildlife habitat, natural resource value, and creek integrity. g. Strengthen contracting process to be more consistent: check all contracts for completion and consistency, coordinate with purchasing office instead of directly through the city attorney's office to streamline contracting process, develop continuing services agreements in addition to our annual services agreements. h. Streamline and coordinate traffic control to require tree care companies subcontract work, or allow tree care contractors to directly invoice Forestry for needed traffic control. i. Train park staff to provide young tree clearance pruning to reduce demand for clearance pruning in parks. j. Explore cost/benefit and funding mechanisms for establishing a second in-house crew.

Timeframe	Cost	Priorities and Actions
Year 1-5	$	**5. Refine the Integrated Pest Management (IPM) Program to improve tree health while minimizing cost and negative impacts to ecosystems and the public.** a. Ensure BMPs are followed for the maintenance of all diseased/infested trees for both public and private property. b. Continually read current scientific literature, attend conferences, consult with researchers, and meet with vendors to identify new solutions to pest problems. c. Annually review and update specifications for applicators. d. Establish pilot program to conduct select injection treatments in-house to reduce contracted cost and increase logistical flexibility. e. Develop a pesticide permitting process for private treatment of public street trees with the notification requirement on the applicator rather than the property owner. f. Evaluate public requests to apply pesticides to public street trees to ensure application will not conflict with city policy or unacceptably impact human health or ecological function.
Year 1-5	$	**6. Streamline the Tree Safety Inspection Program (TSIP) to manage risk and minimize City exposure to claims as well as reduce the financial and logistical costs on forestry operations.** a. Ensure that forestry staff are Tree Risk qualified through the International Society of Arboriculture and that risk assessments are conducted by qualified arborists. b. Document TSIP processes to facilitate its transition to Beehive. Explore whether tree risk can be managed through other existing programs and workflows after Beehive transition. c. Reduce size of program by streamlining hazard surveys and developing specific, stringent guidelines for trees to be included in program and a process for removing trees from program when risk is mitigated through pruning or target relocation. d. Develop guidelines for using different classes of inspection that are proportional to likely tree risk and reasonable given the size of the resource. e. Shift to industry recommendations for inspection of hardware (cables/bracing) in public trees.

Timeframe	Cost	Priorities and Actions
Ongoing	**$$**	**7. Continue implementation of the EAB response strategy to maintain public safety, ecosystem services, and forest function in the face of unprecedented canopy loss.** a. Continue to partner with Colorado EAB Response team on EAB management including biocontrol releases. b. Increase the diversity of tree species on public property and induce or incentivize planting on private property and through development. c. Evaluate public ash scheduled for treatment annually and ensure trees still meet criteria for treatment. d. Continue to proactively remove ash before they present an unacceptable risk to the public or overwhelm staff management capacity. e. Strengthen and continue collaboration with other departments to assist with private tree enforcement. f. Increase the timeframes for compliance with enforcement of private property tree removals to allow for local contractors' scheduling concerns, and send "pre-notices" for property owners so they have more time to react before trees become higher risk. g. Control invasive plants by collaborating with other departments on the re-vegetation of existing natural areas. h. Train Public Works staff to monitor trees along bike paths under Public Works jurisdiction for public safety.
Year 1-5	**$**	**8. Transition to a common software Asset Management System to allow efficient forestry business processes across city work groups and provide essential baseline data for strategic forest management.** a. Document data management processes for transition to Beehive. b. Conduct staff trainings to ensure business process implementation for Beehive. c. Develop, adopt and execute uniform work flows for asset management software across City work groups programs. d. Adhere to uniform business processes for data entry and management to ensure the tree inventory remains up-to-date, accurate, functional across work groups, and resilient to employee turnover. e. Ensure all private pesticide applications to public trees are entered into the Forestry Asset Management System. f. Develop protocol for documenting and protecting habitat of protected species on Forestry assets during Beehive transition. g. Streamline the integration of information collected from the Citizen Science 100 Resilient Cities program into city databases. h. Conduct a resource analysis every ten years, including population, structure, replacement value, and tree services. i. Conduct a canopy analysis every ten years, including land cover, ecosystem services, changes over time, and land use.

Timeframe	Cost	Priorities and Actions
Ongoing	$	**9. Continue to explore all wood utilization options to improve resiliency to increased cost or disappearance of any single waste stream.** a. Continue to divert all wood resources away from the landfill. b. Develop distribution processes for all wood resources and document the annual amount of wood re-purposed and its end-use. c. Continually evaluate new end-uses for urban wood waste and process improvements for woodlot.
Year 6-10	$$	**10. Explore the expansion of the Commercial Tree Program (CTP) beyond the immediate downtown area to maintain urban tree canopy, protect property and better manage public safety issues.** a. Analyze inventory data and determine cost to expand program focusing on higher priority areas such as those with less canopy coverage. b. Coordinate with Community Planning and Sustainability to ensure all landscaping requirements for both public and private property are met and enforced. c. Build a database of commercial properties with potential planting sites and owner contact information to assist with future outreach efforts.
Year 1-5	$	**11. Develop a staff succession plan within Forestry to encourage continual professional development and facilitate transitions in leadership to minimize disruption to operations.** a. Formalize policies to develop personnel capable of assuming leadership positions. b. Identify minimum educational and certification requirements for supervisory positions and make time and resources available to junior staff to pursue those qualifications. c. Encourage and accommodate employee participation in trainings, particularly supervisory trainings. d. Conduct regular staff trainings on asset management software, young tree structural pruning, and emerging urban forest challenges and opportunities.
Ongoing	$	**12. Deliver a State of the Urban Forest Report biennially for elected officials, key urban forest stakeholders, and the public.** a. Include updated benchmark numbers for trees planted, removed, pruned, and changes to the overall community urban forest. b. Integrate into Annual Plan reviews.

PROTECT

The urban forest represents a valuable asset, one which must be nurtured and protected. One of the key directions from the stakeholder interviews and community meetings was a directive to maintain and preserve existing trees. This is accomplished through municipal code, policies, and design and construction standards that support tree planting and longevity. In most cases, these code revisions are small adjustments to sound existing policies.

The following priorities and actions support this goal:

Timeframe	Cost	Priorities and Actions
Year 1-5	$$-$$$	**1. Strengthen Boulder Forestry's role in all city CIP projects to minimize damage to tree assets and canopy loss.** a. Emphasize public trees as essential infrastructure and the need to preserve individual trees and maintain urban tree canopy in light of climate change. b. Prioritize the upgrade of streetscaping along arterials to allow for trees long-term through Capital Improvement projects, including installation of water-efficient, permanent irrigation systems (example locations include 30th St, Iris Ave.). c. Participate in the development of Park Design and Construction Standards, processes, and contract templates. d. Collaborate with CIP project teams to identify best way to formalize Forestry participation in the planning process to identify potential impacts on trees and advise on alternative or mitigative approaches. e. Formalize Forestry participation during construction so that impacts to trees can be monitored and minimized. f. Formalize Forestry participation post-construction to ensure follow-up care on newly planted trees and enforce warranty replacements. g. Increase the planting of large maturing, drought tolerant species on all public projects requiring improved tree diversity. h. Require mitigation for significant, desirable public trees removed through CIP projects when equal public replacements cannot be planted on-site. Provide multiple options for mitigation calculations rather than only appraised value to ensure equitable calculations and minimize staff time. i. Require adequate planting space (soil volume) for all new tree plantings based on industry BMPs. Integrate structural cells whenever possible, and as funding allows, in commercial areas for all projects. j. Require, through code, all new plantings have a water efficient, permanent irrigation system maintained for the life of the tree. k. Explore hiring temporary forestry inspectors for bond-related parks and transportation CIP projects involving trees. l. Review policies and enforcement for slacklining pilot project utilizing trees in city parks.

Timeframe	Cost	Priorities and Actions
Year 1-5	$	**2. Strengthen existing city requirements for trees on Public Property to increase tree protection, improve site preparation, and strengthen tree species diversity requirements to maintain the urban tree canopy and increase forest resiliency.** a. Review and update current ordinances and the city Design and Construction Standards to reduce ambiguity in tree protection standards, increase requirements for tree planting and diversity, emphasize location of new trees for urban heat island mitigation, and develop guidelines for tree management and planting to accommodate both a growing urban tree canopy and solar panels. b. Review approved public tree planting list biennially to add or replace species based on performance or new information. Maintain species list as a separate document from code or standards to streamline updates. c. Require adequate planting space (soil volume) for all new tree plantings based on industry BMPs. Integrate structural cells with stormwater inlet option whenever possible in commercial areas for all projects. Consider permaculture concepts to build soil nutrition and capture rainwater. d. Improve stormwater management with green infrastructure on public property through private development, including minimum green infrastructure requirements for new and redeveloped sites. e. Require all new plantings have a water efficient, permanent irrigation system maintained for the life of the tree. Enforce existing requirements for irrigation and mulching for public street trees by adjacent property owners. f. Formalize consequences for unpermitted pesticide applications to public trees. Update code to address enforcement and penalties.

Timeframe	Cost	Priorities and Actions
Year 6-10	$$	**3. Strengthen existing and develop new city requirements for Private Property to increase tree protection, improve site preparation, and strengthen tree species diversity requirements to maintain the urban tree canopy and increase forest resiliency.** a. Benchmark tree protection and diversity requirements for other cities as a comparison. b. Develop five-year public engagement plan for city code, city manager rule, policy, and guideline updates. Update codes to align with the community vision for tree protection and mitigation for private property trees and phase in gradually over a specified period of time. c. Update tree protection requirements in city codes and City of Boulder Design and Construction Standards and related permitting processes to protect and prevent the removal of existing trees prior to acquiring an approved landscape plan. d. Require mitigation for significant, desirable private trees removed through development projects when replacements cannot be planted on-site. Provide multiple options for mitigation calculations rather than only appraised value to reduce staff time needed. e. Update codes to improve, inspect and enforce long-term maintenance of landscape requirements on private property. f. Add personnel necessary to oversee and monitor tree protection during construction on private property. g. Require adequate planting space (soil volume) for all new tree plantings based on industry BMPs. Integrate structural cells with stormwater inlet option whenever possible in commercial areas for all projects. Consider permaculture concepts to build soil nutrition and capture rainwater. h. Improve stormwater management with green infrastructure on private property through private development, including minimum green infrastructure requirements for new and redeveloped sites. i. Review parking lot shade guidelines and enforcement. Strengthen policies to provide increased shade within a 20-year establishment period. j. Update codes to add appeals process for enforcement of tree nuisance abatement on private property and lengthen the timeframe for remedy to timeframe appropriate for tree and site conditions.

Timeframe	Cost	Priorities and Actions
Year 1-5	$	**4. Revise licensing requirements for all tree care companies performing tree work in Boulder to improve public safety and tree health.** a. Explore requirement for all licensed tree contractors to obtain the ISA certified arborist certification and provide proof of formal safety training by licensees. b. Use meetings, newsletters, and trainings to increase contact with licensees, strengthen the high-quality of tree care, and ensure knowledge of pertinent city codes. c. Continue to increase accessibility of licensing process and website to accommodate different languages and disabilities. d. Formalize protocol for responding to wildlife in trees during pruning or removal operations for both city staff and contractors. e. Develop protocol for response by contractors when conflict with protected animal species cannot be avoided. f. Develop enforcement mechanism to ensure company compliance with all licensing requirements, city codes and natural resource protection requirements.

ENGAGE

The Boulder community places a high value on environmental stewardship. In the development of the UFSP, many stakeholders expressed a desire for a community-based urban forest advocacy group to support environmental stewardship and promote, protect, and enhance Boulder's urban forest. Connecting with and educating the community with the most current information on the urban forest will mobilize activists and facilitate policy implementation. Specific priorities include; opportunities to establish and promote a deeper understanding of the year-round benefits of trees, challenges and opportunities facing the urban forest, opportunities for volunteers and collaboration, updates to the Forestry website, the development of specific outreach materials for new plan components (e.g., drought, landscaping, EAB), and print material outreach such as updated door hangers.

Priorities to engage the community are; communicating UFSP goals and plans, diversifying funding sources and partners, facilitating private property tree plantings and maintenance, establishing a partner non-profit urban forest foundation and using the forestry website, flyers, tabling events, tree talks, and social messaging to connect with the Boulder community.

The following priorities and actions support this goal:

Timeframe	Cost	Priorities and Actions
Year 1-5	$	**1. Provide the community with balanced and objective information to assist them in understanding the problems, alternatives, and options to achieve the Boulder urban tree canopy goal.** a. Formalize clear and consistent design and language for Boulder Forestry outreach materials. i. Hire a professional firm to develop and execute a consistent outreach strategy outside of the capacity of the department. ii. Coordinate the outreach strategy as citywide rather than a departmental effort. iii. Communicate no-net-loss goal to the community and engage them in identifying and executing solutions. Create a call to action and clearly articulate "Why Now?" iv. Share and promote Boulder Forestry's vision, capabilities, and expertise to increase public support and willingness to fund and expand Boulder Forestry's role. v. Encourage community members to act in urgency to the predicted decline of the urban tree canopy. a. Systematically contact commercial property owners list directly and via DBI/DMC newsletters to engage with tree maintenance activities such as watering, replacing mulch, etc. to maintain tree health. vi. Promote public tree planting plan for the community to support the Urban Tree Canopy goal including; prioritized areas, diversification goals, and maintenance guidelines. vii. Promote drought preparedness messaging to the community to minimize loss and/or damage including; basic steps to conserve water

Timeframe	Cost	Priorities and Actions

while preserving trees, when and how much to irrigate trees, how to conduct simple inspections of their irrigation system, and identify over watering and advantages of drought tolerant trees compared to low water use trees.

viii. Promote the public tree EAB response plan for the community to provide the available community actions to respond constructively to the anticipated impact.

a. Increase public outreach and notification so residents are aware of full scope of EAB impact and urgency and what they can do to support and sustain the urban canopy.

b. Develop outreach campaign for applicators and residents to increase awareness and compliance with pesticide permitting process.

c. Promote timely removal and replacement of dead/dying ash trees on private property for safety.

d. Develop sign designs and a plan for ash tree removals in high traffic areas, like the Boulder Creek Path for education and awareness for community members and visitors.

e. Inform public of vetted resources available, such as the planting plan, for replacement options to support canopy goals and public safety.

ix. Promote individual forestry programs and respective strategies, especially sensitive programs such as Integrated Pest Management.

x. Update Boulder Forestry notification door hangers;

a. Evaluate the tree removal notification process to ensure residents understand the timeline and reasons for specific tree removals.

b. Develop educational door hangers (i.e. cartoon of thirsty tree to get residents to water routinely).

c. Develop door hangers to explain why some trees must be treated with pesticides.

b. Continue to update and improve the Boulder Forestry website.

i. Increase user access to key information and resources.

ii. Publicize current canopy characteristics such as population size, diversity, and ecosystem services compared to 2037 goals.

iii. Maintain a public-facing tree inventory platform for resident information, requests. This platform can also serve as a place to calculate and publicize ecosystem services.

iv. Add a dynamic map of contracted work and rotational pruning schedules.

v. Provide easy access to or integrate licensing and permitting process workflows.

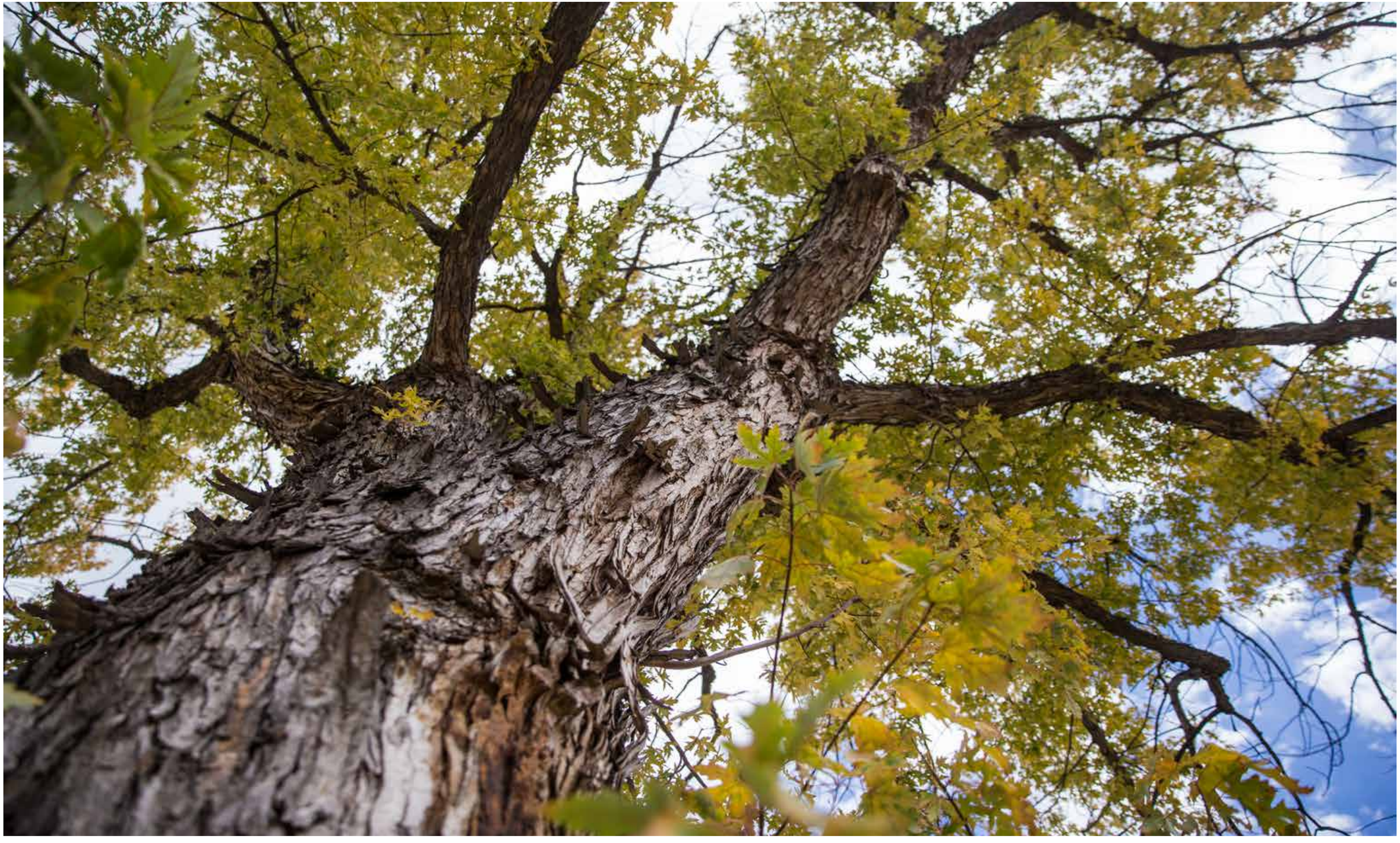
vi. Highlight interesting and fun apps and tools already available, such as the Notable Tree List and public tree identification.

vii. Develop a digital platform for people to build community through shared passion for trees and the natural environment.

Timeframe	Cost	Priorities and Actions
		viii. Educate the public about why and which pesticides are used. ix. Provide transparent budget and cost information for all policy actions. x. Create a system for public suggestions for process improvement ideas. c. Continue existing youth educational programs. i. Continue partnership with city utilities to educate youth about trees through the Water Festival. ii. Continue seedling giveaway to Boulder Valley School District elementary students. d. Collaborate with private tree care companies to disseminate outreach materials and educate residents on behalf of Boulder. e. Increase the use of social media (e.g., Facebook, Twitter) to better communicate with residents to build advocacy.
Year 1-5	$	**2. Partner with the community on projects to broaden knowledge, support and funding for the Boulder urban tree canopy goal.** a. Support the development of a non-profit urban forest foundation or tree trust to support canopy goals and management. i. Facilitate the development of a staff leadership team to direct the vision and capacity building of the emerging non-profit. ii. Define the level of resources, staff, and funding that the department will allocate to a non-profit partner. iii. Define success criteria for continued support of a non-profit. iv. Identify and develop strategies with partners to solve community challenges through trees, for example: jobs training for youth. v. Explore partnerships that can identify and support opportunities for grants, diversified funding, new partnerships, crowd-funding, etc f. Continue to work with partners to expand waste utilization strategies to accommodate anticipated increase in debris. i. Develop new or expand existing wood product markets for wood utilization. ii. Communicate opportunities to end-users of wood to maximize re-use. c. Identify and develop strategies with partners to remove barriers to volunteer participation for all community members, such as webinars to aid with time challenges.

Timeframe	Cost	Priorities and Actions
Year 1-10	$$	**3. Develop and expand opportunities for community involvement in the commitment to achieve the Urban Tree Canopy goal.** a. Continue to engage neighborhoods with volunteer tree planting events. Prioritize those areas with lower urban tree canopy or those greatly impacted by EAB. b. Identify and partner with vendors or sponsors to defray planting and ash removals costs for private property owners. i. Continue to facilitate and/or subsidize tree planting for private property owners through existing tree-giveaways and sales. ii. Explore partnerships that can identify and support opportunities for grants and financial assistance for low-income residents and non-profits to facilitate tree removal and planting or help defray costs. iii. Provide cost-sharing, free replacement trees, or incentives for private property tree planting. iv. Explore options for grants and financial assistance or a payback program for low income residents or non-profits to facilitate tree removal costs. v. Offer mini-grants to subsidize private plantings and assist neighborhoods in tree planting efforts. vi. Work strategically with other Boulder Forestry programs to source high-quality, diverse, low cost nursery stock. Tree requests are made online and distributed at neighborhood events to facilitate easy transport. vii. Provide information on proper tree planting and free mulch at tree giveaways/sales. viii. Develop strategies to remove barriers to participation for all community members. ix. Ensure tree planting programs are championed by an NGO or community leader to provide an alternative and effective voice in communicating the critical nature of the current situation. c. Recruit and train committed volunteers. i. Assist with forestry maintenance activities and general support. ii. Emulate tactics from local other local organizations that are successful in activating volunteers. iii. Educate engaged advocates that understand the community's unique urban forestry challenges, opportunities, policies, and funding sources. iv. Develop and implement additional youth engagement opportunities. a. Develop additional opportunities such as photo contests, apps, interactive websites, etc. b. Coordinate with BVSD on an environmental educational program for elementary-aged children. c. Develop an arborist/green industry job training program for youth.

Timeframe	Cost	Priorities and Actions
		v. Develop a community urban forestry newsletter collaboration between Boulder Forestry staff and volunteers. vi. Provide opportunities for volunteers to take on leadership roles. Trainees become advocates for the urban forest, armed with knowledge of area trees, policies, and threats. d. Perform community satisfaction measurements and track participation in outreach events. i. Create and deliver biannual surveys for urban forest stakeholders to ensure that management strategies continue to be aligned with the community's vision for the urban forest. ii. Conduct annual UFSP reviews; update available resources, opportunities, and changes in community expectations.
Year 1-5	**$**	**4. Involve the public on the analysis, alternatives, and recommendations for further urban forestry related planning processes and potential code changes.** a. Provide multiple opportunities for input from the public on Boulder Forestry Emergency Response Plan and Urban Ecosystems Management Plan. b. Work with an outside consultant to develop a five-year public engagement plan for City code, city manager rule, policy, process and guideline updates pertaining to both public and private property trees. c. Convene a group of stakeholders to review benchmarks and develop options and recommendations. d. Hold community listening sessions to gauge public support for input on updates to City codes and policies. e. Provide multiple opportunities for feedback; require a clear and transparent process with the community.



How Are We Doing?

Monitoring and Measuring Results

The UFSP is a living document and city staff must identify timeframes for reviewing accomplishments and updating targets dates for action items.

Annual Plan Review and Update

The UFSP is an active tool that will guide management and planning decisions over the next 20 years. The goals, priorities, and actions will be reviewed yearly for progress and integration into annual work plans. The UFSP presents a long-range vision with timeframes that are intended to be flexible. This will allow management to adapt in response to emerging opportunities, available resources, and changes in community expectations. Each year, specific areas of focus should be identified, which will inform budget and time requirements for urban forest managers.

Resource Analysis

Boulder urban forest managers can update the tree resource analysis over time and in conjunction with inventory database updates. The structure, replacement value, and tree services were initially quantified in 2015. Future studies can compare changes against these benchmarks. This allows for the evaluation of changes in tree condition, species diversity, services, and overall resource value. A recommended action of the UFSP is to complete this analysis every ten years to illustrate progress and success towards UFSP goals.

Canopy Analysis

Canopy changes can occur gradually or suddenly. Using GIS analysis, managers can measure and illustrate changes in overall land cover as well as by neighborhood and land-use. This information can be used to inform canopy goals and monitor attainment. A canopy study should be conducted every ten years, or after major canopy-impacting events as needed.

State of the Urban Forest Report

This report, delivered to elected officials and key urban forest stakeholders every two years, includes numbers of trees planted and removed, and changes to the overall community urban forest (e.g., structure, services, and value). It will serve as a performance report to stakeholders, and as an opportunity for engagement. The data will be used to highlight the successful attainment of UFSP priorities as well as to inform stakeholders about any issues or stumbling blocks. This information can be integrated into urban forest managers' Annual Plan Reviews and be used to pursue additional project support and funding.

Community Satisfaction

The results of the UFSP will include measurable improvements to efficiency and reductions in maintenance costs. Over time, Boulder will need to prepare people for bigger and longer-term benefits. Achievement of UFSP goals will affect several positive changes. These changes will support better tree health and greater longevity, and also help prevent tree failures. Meeting community expectations for the care and preservation of the urban forest resource is an important measure of success. Community satisfaction can be measured through surveys, community meetings, and public support for the UFSP. Community satisfaction can also be reflected by the level of engagement and support for urban forest programs. A periodic survey of urban forest stakeholders will help managers ensure that management strategies continue to be aligned with the community's vision for the urban forest.

Appendix

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Methodology

This section will discuss and define the methodologies used for specific calculation referenced in the Plan:

i-Tree Canopy

Air Quality

The i-Tree Canopy v6.1 Model was used to quantify the value of ecosystem services for air quality. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports air pollutant removal rates and monetary values for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM) (Hirabayashi 2014).

Within the i-Tree Canopy application, the U.S. EPA's BenMAP Model estimates the incidence of adverse health effects and monetary values resulting from changes in air pollutants (Hirabayashi 2014; US EPA 2012). Different pollutant removal values were used for urban and rural areas. In i-Tree Canopy, the air pollutant amount annually removed by trees and the associated monetary value can be calculated with tree cover in areas of interest using BenMAP multipliers for each county in the United States.

To calculate ecosystem services for the study area, canopy percentage metrics from Urban Tree Canopy land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for each of the five listed air pollutants.

Carbon Storage and Sequestration

The i-Tree Canopy v6.1 Model was used to quantify the value of ecosystem services for carbon storage and sequestration. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports carbon storage and sequestration rates and monetary values. Methods on deriving storage and sequestration were drawn from academic research (Nowak et al. 2013).

To calculate ecosystem services for the study area, canopy percentage metrics from Urban Tree Canopy land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for carbon storage and sequestration.

i-Tree Hydro

The i-Tree Hydro v5.0 Model was used to quantify the value of ecosystem services for stormwater runoff. i-Tree Hydro was designed for users interested in analysis of vegetation and impervious cover effects on urban hydrology.

This most recent version (v5.0) allows users to report hydrological data on the city level rather than just a watershed scale giving users more flexibility. For more information about the model, please consult the i-Tree Hydro v5.0 manual (http://www.itreetools.org).

To calculate ecosystem services for the study area, land cover percentages derived for the project area and all municipalities that were included in the project area were used as inputs into the model. Precipitation data from 2005-2012 was modeled within the i-Tree Hydro to best represent the average conditions over an eight year time period. Model simulations were run under a Base Case as well as an Alternate Case. The Alternative Case set tree canopy equal to 0 percent and assumed that impervious and vegetation cover would increase based on the removal of tree canopy. Impervious surface was increased 0.8 percent based on a percentage of the amount of impervious surface under tree canopy and the rest was added to the vegetation cover class. This process was completed to assess the runoff reduction volume associated with tree canopy since i-Tree Hydro does not directly report the volume of runoff reduced by tree canopy. The volume (in cubic meters) was converted to gallons to retrieve the overall volume of runoff avoided by having the current tree canopy.

Through model simulation, it was determined that tree canopy decreases the runoff volume in the project area by 15,001,357 gallons per year using precipitation data from 2005-2012. This equates to approximately 5,408 gallons per acre of tree canopy (15,001,357 gals/2,774 acres).

To place a monetary value on stormwater reduction, the cost to treat a gallon of storm/waste water was given by the local partners. This value was $0.0118 per gallon. Tree canopy was estimated to contribute roughly $177,016 to avoid runoff annually to the project area.

Funding

ADDITIONAL FUNDING NEEDED EACH YEAR TO ACHIEVE UFSP GOALS (includes annual 3% increase for inflation)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2033	2038	NOTES
Rotational Pruning													Recommendation is to move to 8-year rotation for all trees. A phased approach is preferred: Move from 14-year to 10-year for trees > 9" DBH, then down to 8-year rotation for trees > 9" DBH then eventually 8 years for all trees.
Phase 1 - move from 15 year to 10 year rotation for public trees >9" DBH	NA	$55,000	$56,650	$58,350	$60,100	$61,903	$63,760	$65,673	$67,643	$69,672	$80,769	$93,634	
Phase 2 - move from 10 year to 8 year rotation for public trees >9" DBH	NA	NA	NA	$50,000	$51,500	$53,045	$54,636	$56,275	$57,964	$59,703	$69,212	$80,235	
Phase 3 - 8 year prune rotation for all public trees	NA	NA	NA	NA	NA	NA	$78,000	$80,340	$82,750	$85,233	$98,808	$114,546	
Subtotal	**$0**	**$55,000**	**$56,650**	**$108,350**	**$111,600**	**$114,948**	**$196,396**	**$202,288**	**$208,357**	**$214,608**	**$248,789**	**$288,415**	
Removals (Non-Ash)													Average # non-ash tree removals is expected to increase due to senescence /public safety concerns for silver maples and impacts due to climate change
Phase 1 - Add'l 50 tree removals/year	$30,250	$31,158	$32,092	$33,055	$34,047	$35,068	$36,120	$37,204	$38,320	$39,469	$45,756	$53,044	
Phase 2 - Add'l 100 tree removals/year	NA	NA	NA	$60,500	$62,315	$64,184	$66,110	$68,093	$70,136	$72,240	$83,746	$97,085	
Phase 3 - Add'l 100 tree removals/year	NA	NA	NA	NA	NA	NA	$60,500	$62,315	$64,184	$66,110	$76,640	$88,846	
Subtotal	**$30,250**	**$31,158**	**$32,092**	**$93,555**	**$96,362**	**$99,252**	**$162,730**	**$167,612**	**$172,640**	**$177,820**	**$206,142**	**$238,975**	
Traffic Control and Towing													Traffic control and towing costs are not currently budgeted and must come out of pruning and removal budgets; funding request based upon average from past 5 years.
Current level of service unfunded	$22,500	$23,175	$23,870	$24,586	$25,324	$26,084	$26,866	$27,672	$28,502	$29,357	$34,033	$35,054	
Phase 1 - increases due to higher # prunes/removals	NA	$11,250	$11,588	$11,935	$12,293	$12,662	$13,042	$13,433	$13,836	$14,251	$16,521	$17,017	
Phase 2 - increases due to higher # prunes/removals	NA	NA	NA	$8,500	$8,755	$9,018	$9,288	$9,567	$9,854	$10,149	$11,766	$12,119	
Phase 3 - increases due to higher # prunes/removals	NA	NA	NA	NA	NA	NA	$40,000	$41,200	$42,436	$43,709	$50,671	$52,191	
Subtotal	**$22,500**	**$34,425**	**$35,458**	**$45,021**	**$46,372**	**$47,763**	**$89,196**	**$91,872**	**$94,628**	**$97,467**	**$112,991**	**$116,381**	
Tree Planting - Facilitate / Subsidize for Private Property													using same guidelines as 2018 Boulder Tree Sale. Phased approach from 150 to 350 trees/year, 500 trees/year then 750 trees/year. Subsidy is $20/tree. Cost could be reduced if subsidy is via private donations. Subsidy not adjusted for inflation.
Phase 1 - subsidy for 350 trees	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	
Phase 2 - subsidy for 500 trees	NA	NA	NA	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	
Phase 3 - subsidy for 750 trees	NA	NA	NA	NA	NA	NA	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	
Subtotal	**$7,000**	**$7,000**	**$7,000**	**$10,000**	**$10,000**	**$10,000**	**$15,000**	**$15,000**	**$15,000**	**$15,000**	**$15,000**	**$15,000**	
Staffing													
Phase 1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phase 2 - coincides with pruning /removal increases	NA	NA	NA	$70,000	$72,100	$74,263	$76,491	$78,786	$81,149	$83,584	$96,896	$99,803	
Phase 3 - coincides with pruning /removal increases	NA	NA	NA	NA	NA	NA	$70,000	$72,100	$74,263	$76,491	$88,674	$91,334	
Subtotal	**$0**	**$0**	**$0**	**$70,000**	**$72,100**	**$74,263**	**$146,491**	**$150,886**	**$155,412**	**$160,075**	**$185,570**	**$191,137**	
TOTAL - Additional Funding Needed	**$59,750**	**$127,583**	**$131,200**	**$326,926**	**$336,434**	**$346,227**	**$609,814**	**$627,658**	**$646,038**	**$664,969**	**$768,492**	**$849,908**	

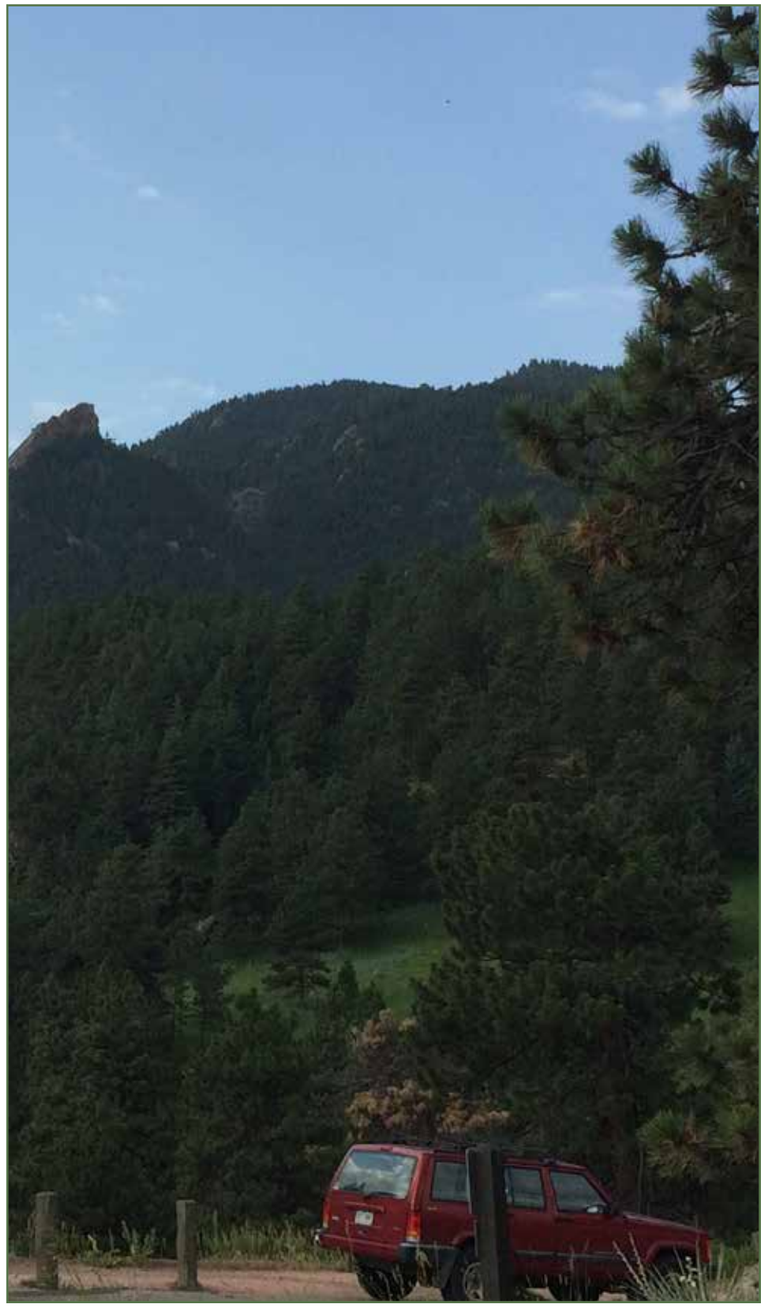
Emerald Ash Borer - Parks & Recreation CIP Funding

	2014 (from Forestry Ops Budget)	2015 (actual)	2016 (actual)	2017 (actual)	2018 (estimated)	2019 (estimated)	2020 (estimated)	2021 (estimated)	2022 (estimated)	2023 (estimated)	2024 (estimated)	2025 (estimated)	2026 (estimated)	2027 (estimated)	2028 (estimated)	NOTES
Tree Planting	Planned prior to EAB detection	$100,000	$73,385	$40,683	$72,833	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	Assumes 600 trees planted / year starting in 2019; planting funding from multiple sources including EAB CIP, Forestry Ops and Mitigation
Pesticide Apps	$25,406	$56,000	$45,504	$23,226	$50,876	$45,000	$25,000	$45,000	$45,000	$25,000	$45,000	$45,000	$25,000	$45,000	$45,000	Treating 1339 public ash trees on 3-year rotation with Tree-age; # trees and cost varies annually depending upon cycle year
Tree Removal	$17,484	$20,000	$72,461	$113,791	$115,000	$125,000	$145,000	$130,000	$130,000	$150,000	$135,000	$52,500	$50,000	$20,000	$20,000	Total cost to remove approx 4500 untreated ash is $1.64 million; total removal cost 2014-2028 = $1.3 million because some trees will be removed with in-house crew
Tree Watering	Forestry Ops budget	$14,100	$19,800	$16,159	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$10,000	$10,000	Costs may fluctuate depending upon weather conditions
Wood Debris	Forestry Ops budget	$13,125	$31,805	$0	$70,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$80,000	$25,000	$20,000	$20,000	fluctuates based upon # of ash trees removed
Spoils Pile (screening/disposal)	Not tracked	$0	$10,000 (Forestry Ops budget)	$0	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	fluctuates based upon # of trees planted
Education / Outreach	Not tracked	Not tracked	Not tracked	Not tracked	$10,000	$15,000	$15,000	$10,000	$10,000	$10,000	$5,000	$5,000	$5,000	$5,000	$5,000	
Miscellaneous supplies	Not tracked	Not tracked	$2,723	$2,432	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$2,500	$2,500	$2,500	$2,500	
Biocontrols	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	USDA APHIS	
TOTAL SPENT	**$42,890**	**$203,225**	**$245,678**	**$196,291**	**$373,709**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$375,000**	**$297,500**	**$272,500**	**$272,500**	
Budgeted	**$0**	**$230,000**	**$246,675 ($220,000 +$26,675 carryover)**	**$220,000**	**$373,709 ($350,000 + $23,709 carryover)**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$375,000**	**$300,000**	**$275,000**	**$275,000**	

Calculating Individual Tree Services

Communities can calculate the services of their urban forest by using a complete inventory (or sample data) in conjunction with the USDA Forest Service i-Tree software tools. This state-of-the-art, peer-reviewed software suite considers regional environmental data and costs to quantify the ecosystem services unique to a given urban forest resource.

Individuals can calculate the services of trees to their property by using the National Tree Benefit Calculator (www.treebenefits.com/calculator) or with i-Tree Design. www.itreetools.org/design).



Public Survey

Survey Regression Analysis

Linear regression models were built to determine survey respondent values towards Boulder Forestry activities and topics. A model comparison approach was used to identify key indicators for 2 topics:

1. Knowledge and feelings about Boulder Forestry and Boulder Forestry activities
2. Factors which influence a person's willingness and degree of participation in a potential tree stewardship program

For the first topic, a model comparison approach was used to identify key indicators for respondents' knowledge and feelings about Boulder Forestry and their activities. First, a single response variable was created by averaging responses to two questions: Q8, 'How familiar are you with the Boulder Forestry responsibilities below?', and Q11C, how well respondents agreed or disagreed with 'Boulder Forestry's policies reflect the values of the Boulder Community' to create a single new metric called 'Knowledge.' All possible explanatory variables were then defined, including the demographic battery from the end of the survey, as well as other values and attitudes around the urban forest.

A linear regression model was created with every combination of six or fewer variables. This resulted in more than 35,000 potential models. Each model was then ranked based on its performance and complexity. If

any two models had the same performance, the one with fewer explanatory variables was deemed preferable. This ranking was quantified using Akaike's information criterion (AIC).

The resulting best-fit model had only two explanatory variables; 'TimeRecycled' and 'FocusGroup', which correspond to Q17A and Q30. Additionally, all of the top-performing models contain these two explanatory variables, and in every model these two indicators have the strongest explanatory effect. When examined more closely, both of these predictors have a significant positive relationship with the variable Knowledge. In other words, the more times per year a person recycles, the more likely they are to be knowledgeable and agree with Boulder Forestry activities. Similarly, those willing to participate in a focus group about urban forest issues are more likely to be knowledgeable and agree with Boulder Forestry activities. This is supported by research that shows that current environmental behavior is associated with a higher level of knowledge about environmental issues*. Given the high rate of recycling in Boulder, this may be a good start for targeted marketing outreach.

For the second topic, two questions were asked: 1) What factors indicate a willingness to participate in a potential tree stewardship program Q14, and 2) To what degree would respondents be willing to participate (i.e. level of tree stewardship) Q15. For both questions a similar approach was used as for the above analysis.

The results for Q14 showed that the explanatory variables included the demographic variables, the new knowledge metric, and questions 3, 7, and 11, which asked about threats to the urban forest, associations between the urban forest and neighborhood quality, and feelings about Boulder Forestry's current activities. These explanatory variables were included given their insight into respondents' feelings about how much threat Boulder's urban forest is under (and therefore Because of the increased number of variables the number of combinations that could be explored was reduced, which created a logistic regression model for all combinations of five or fewer explanatory variables. This resulted in over 16,000 models. For Q15, the same approach was taken, with the same explanatory variables. Because responses to Q15 have multiple levels, a multinomial logistic regression was used. Again, a regression was compared for every combination of five or fewer explanatory variables, producing 16,000 models. For Q15, explanatory variables were added to the model and ranked on its probability that it explains respondents' level of participation to the question. These levels of participation are:

1. No response
2. None of them. This is the responsibility of Boulder Forestry and should be covered by current taxes
3. I would like to help out but am unable/it's not feasible to do so
4. I would be willing to occasionally water a tree outside my business/residence/workplace
5. I would be willing to water and maintain a tree outside my business/residence/workplace
6. I would participate in tree planting
7. I would participate in youth education.

The most likely response is to not participate (2), which indicates a bit of an uphill battle to get residents to participate in a tree stewardship program. Comments from the 'other' response category in the long-form survey shed some light on this reluctance. Many indicated that age and health issues are a barrier to increased participation, as well as time limitations and a lack of specific information on specific trees.

For those willing to engage in some level of tree stewardship, the results indicate that the best models all identify:

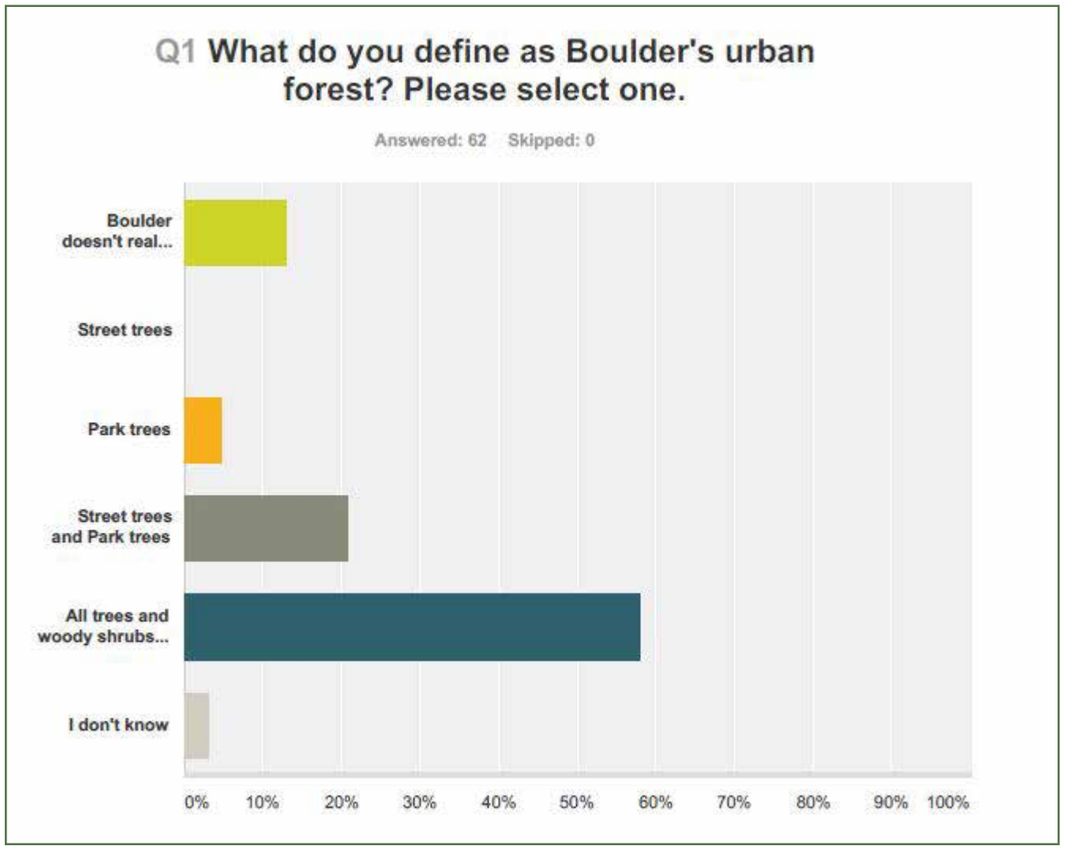
- Participating in a focus group
- The knowledge variable developed above, and
- Feeling at home (Q18)

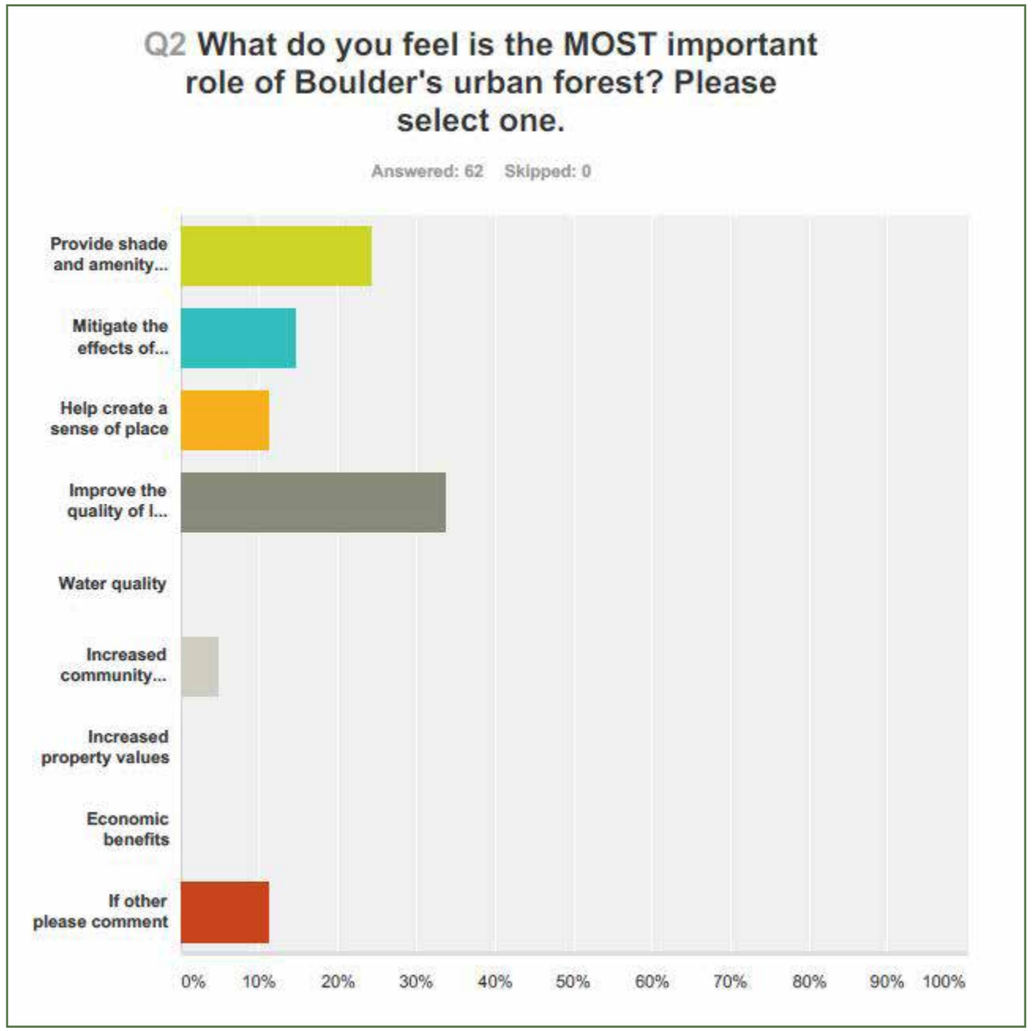
As the key explanatory variables. This is not surprising given that those who are more willing to educate themselves about Boulder Forestry activities, who agree with them, and who are willing to participate in a focus group, are more likely to 'help out' through tree stewardship. Similarly, Feeling at home, which is linked to attachment to one's community, has been linked to an increased likelihood of environment action (*). Given the priority in the 2015 BVCP over quality of life and sense of place, as well as links above between trees and neighborhood quality, it would be prudent to link Boulder Forestry activities to supporting and enhancing the quality and sense of place for residents' neighborhoods as one aspect of the marketing and outreach campaign. This is particularly true given the emotional and personal connection many residents expressed to trees in the Tree Story outreach and comments in the survey.

Survey Graphs

Long-Form Survey Questions

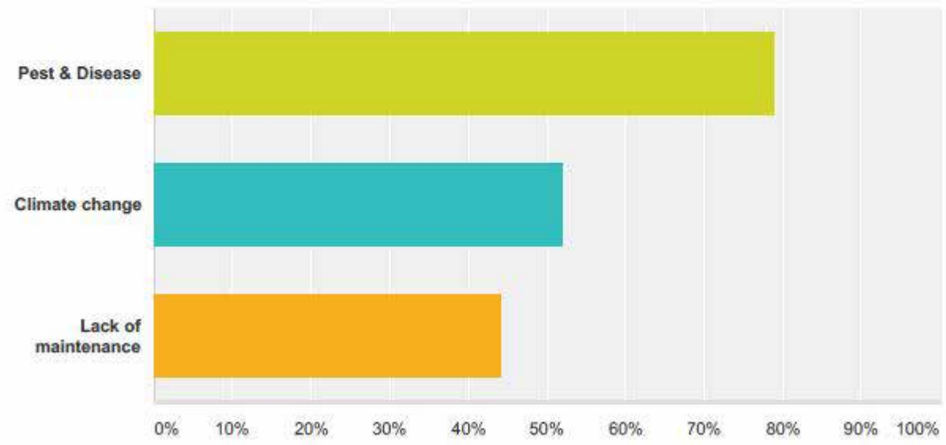
The following charts represent th responses to the 2Forks long-form survey questions. Charts were created only from questions with easily graphed responses. Some questions, such as open response questions, were not charted. Thus, some questions do not have a chart.





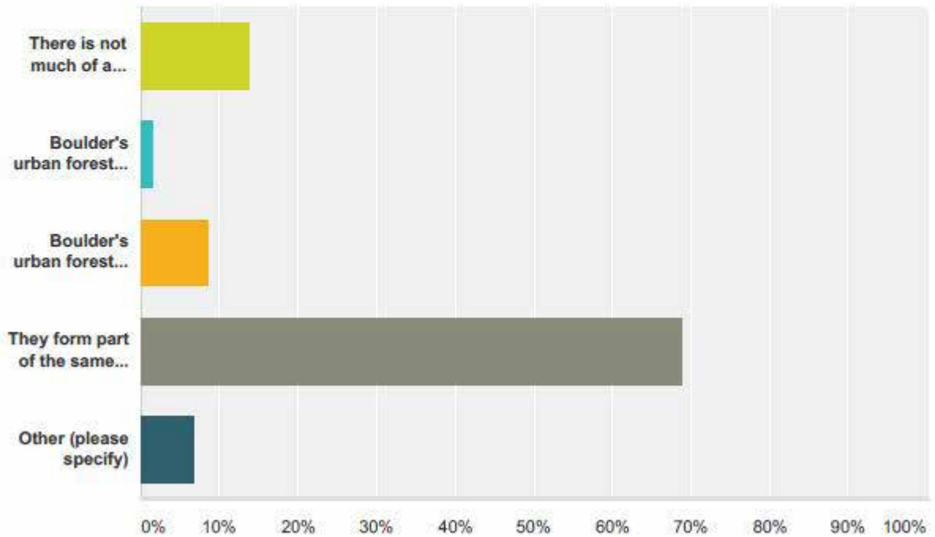
Q3 Which of the following do you feel are threats to the urban forest in Boulder? Select all that apply.

Answered: 52 Skipped: 10



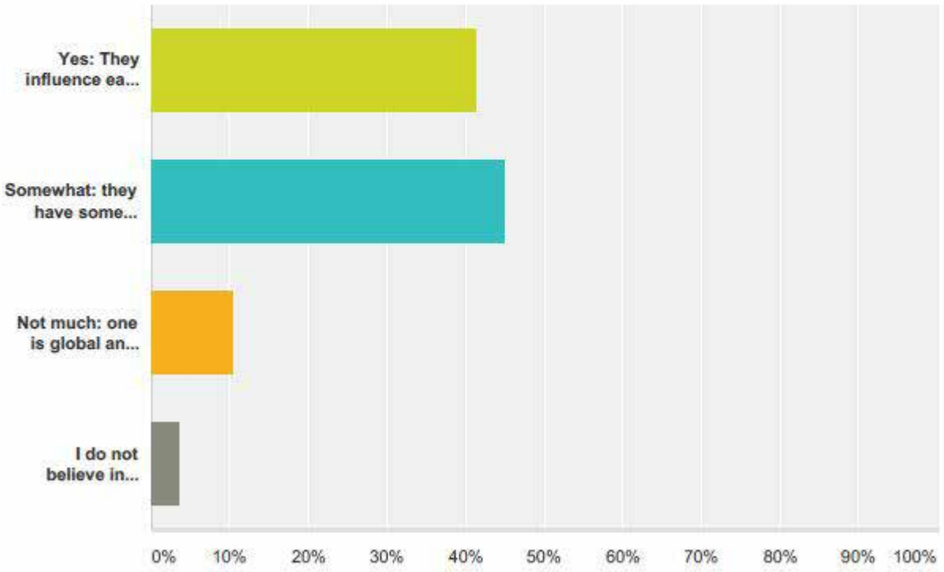
Q5 What do you feel is the relationship between Boulder's urban forest and nature surrounding the city? (Open space mountain parks).

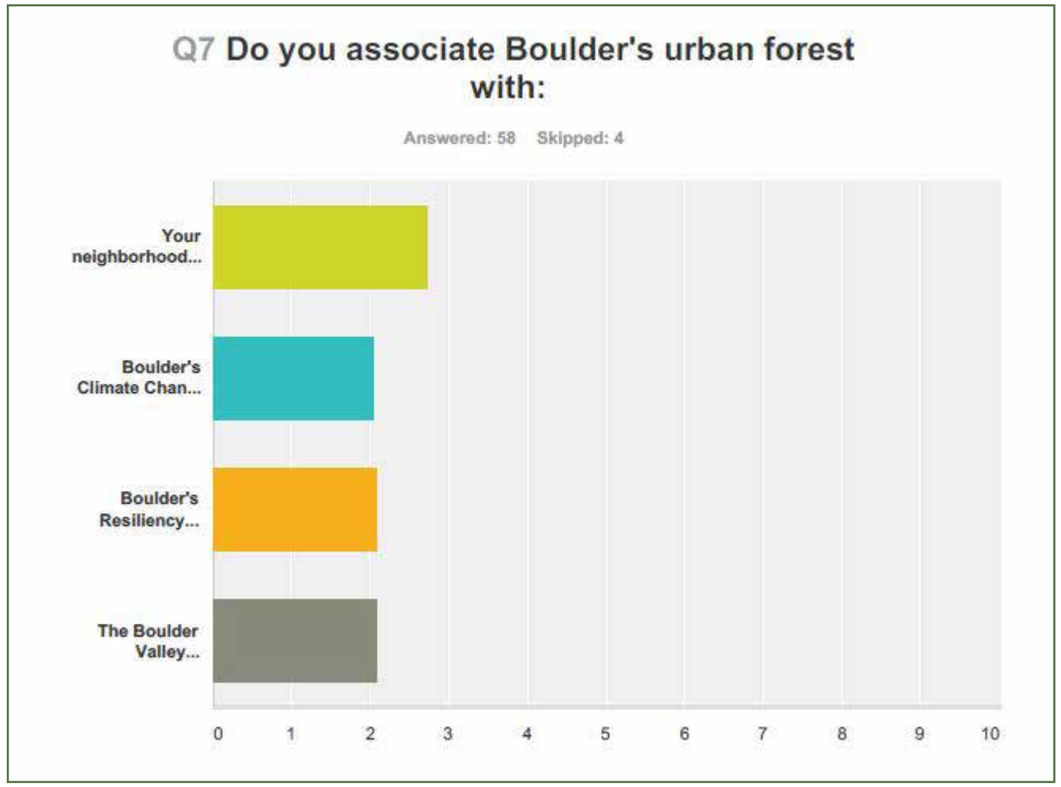
Answered: 58 Skipped: 4

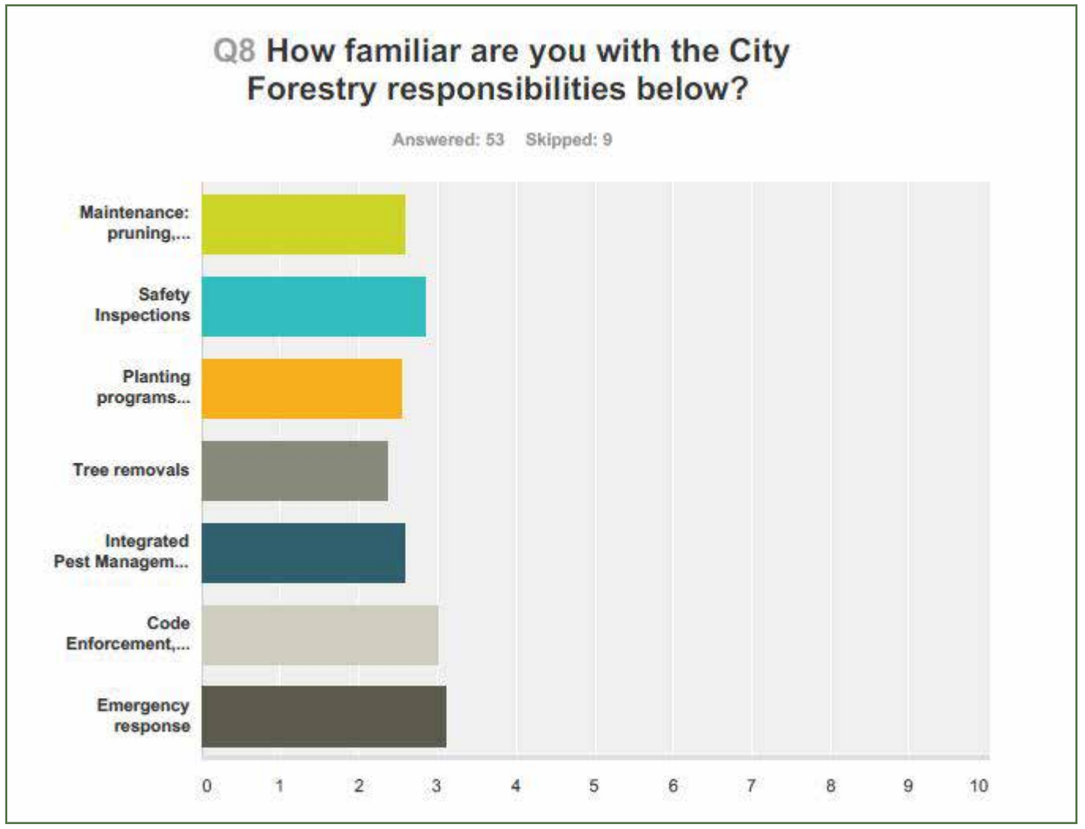


Q6 Do you feel there is a relationship between the urban forest in Boulder and climate change?Please select one.

Answered: 58 Skipped: 4

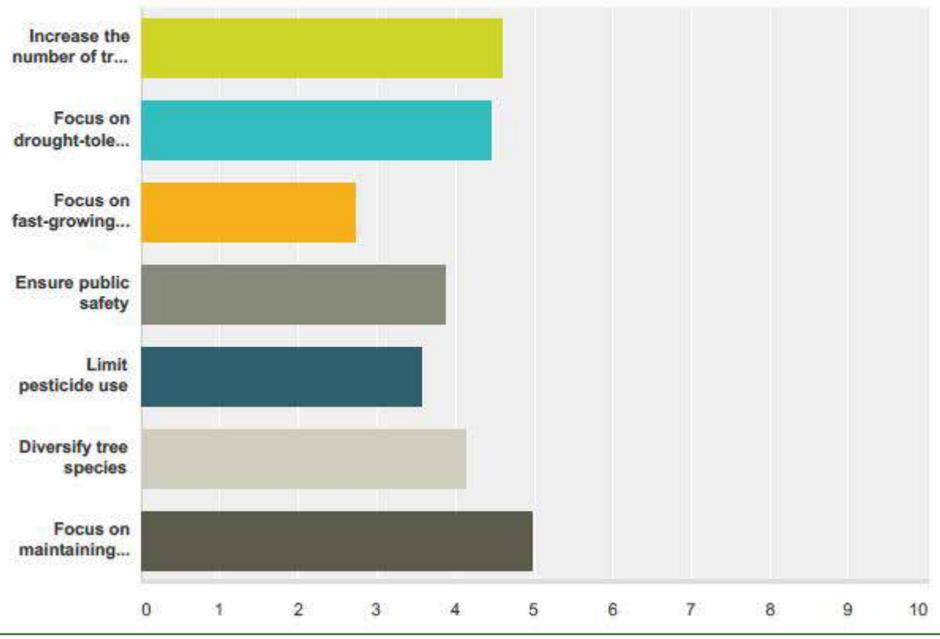



Q7 Do you associate Boulder's urban forest with:
Answered: 58 Skipped: 4
Your neighborhood...
Boulder's Climate Chan...
Boulder's Resiliency...
The Boulder Valley...
0 1 2 3 4 5 6 7 8 9 10


Q8 How familiar are you with the City Forestry responsibilities below?
Answered: 53 Skipped: 9
Maintenance: pruning,...
Safety Inspections
Planting programs...
Tree removals
Integrated Pest Managem...
Code Enforcement,...
Emergency response
0 1 2 3 4 5 6 7 8 9 10

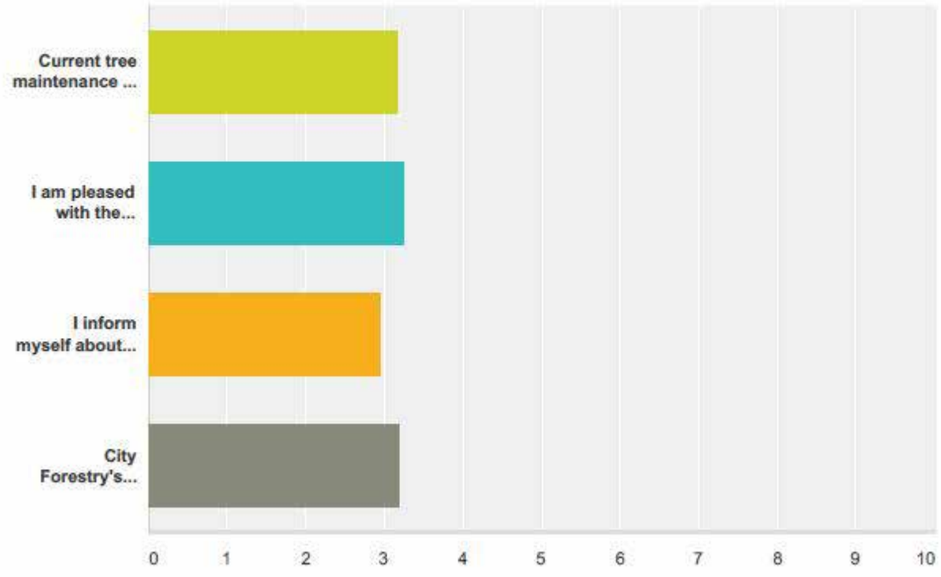
Q10 Please rate the following City Forestry goals in order of importance to you, 1 being the most important and 7 being the least.

Answered: 53 Skipped: 9



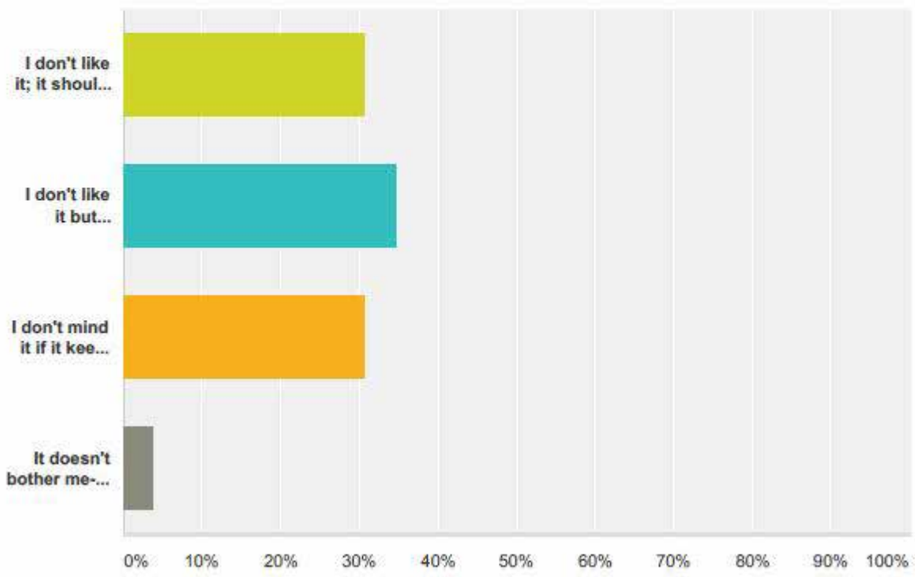
Q11 Please rate to what extent you agree or disagree with the following statements.

Answered: 53 Skipped: 9



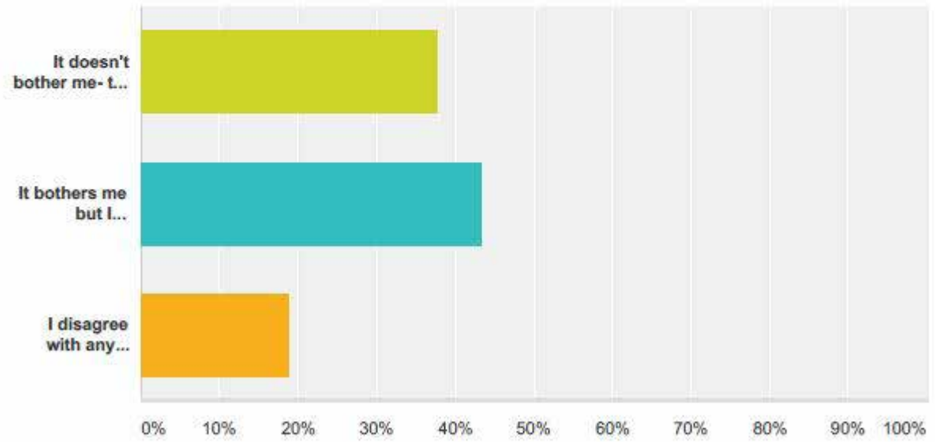
Q12 Please tell us how you feel about tree removal activities by City Forestry.Please select one.

Answered: 52 Skipped: 10



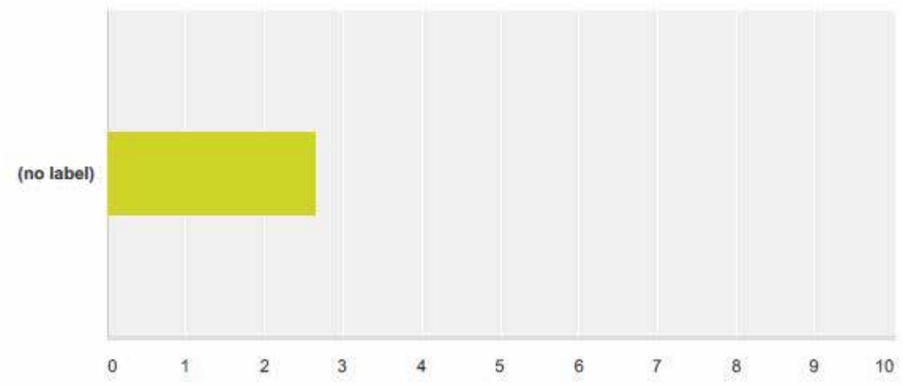
Q13 City Forestry only uses insecticides when the life/health of a mature tree is threatened and alternative products (i.e. botanicals such as rosemary oil) are used whenever possible. When a non-botanical insecticide is used, it is injected into the trunk of the tree to reduce public exposure.Please tell us how you feel about insecticide use by City Forestry.

Answered: 53 Skipped: 9



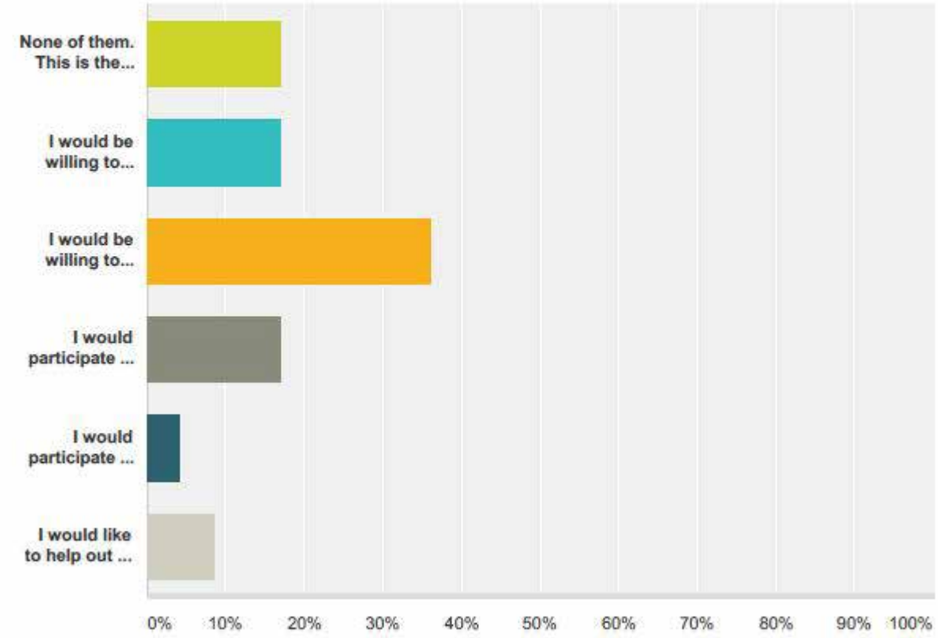
Q14 What is your level of interest in participating in a tree stewardship program?

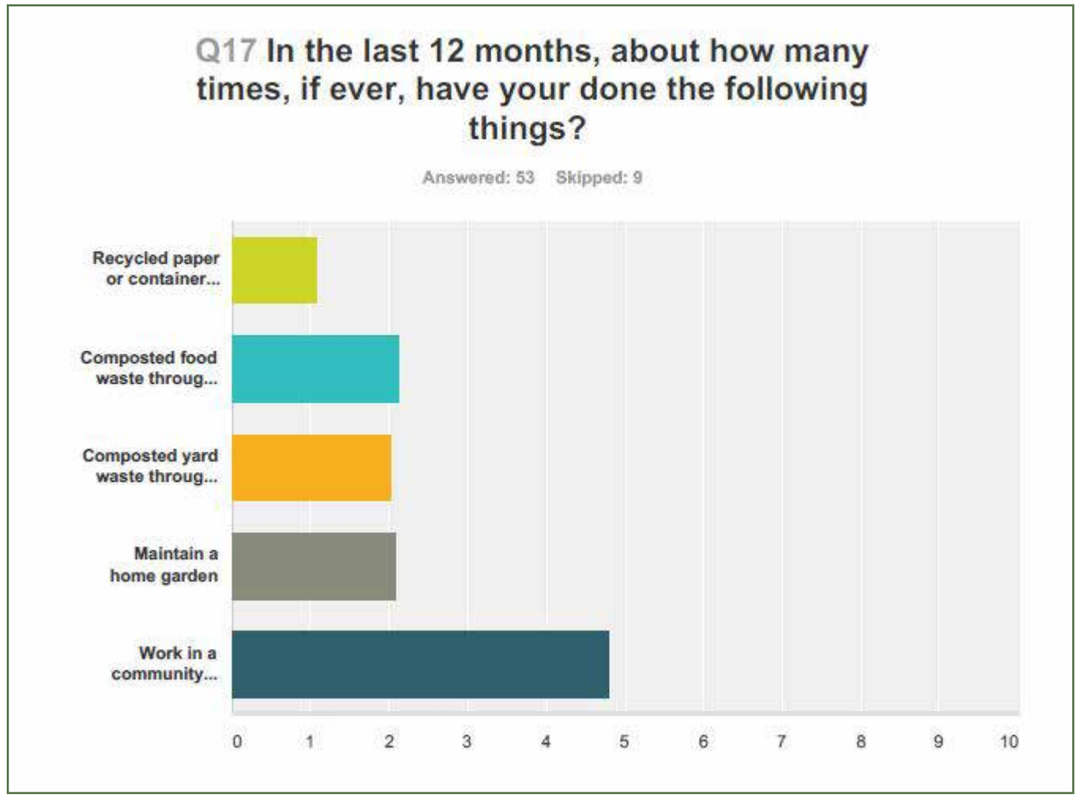
Answered: 52 Skipped: 10

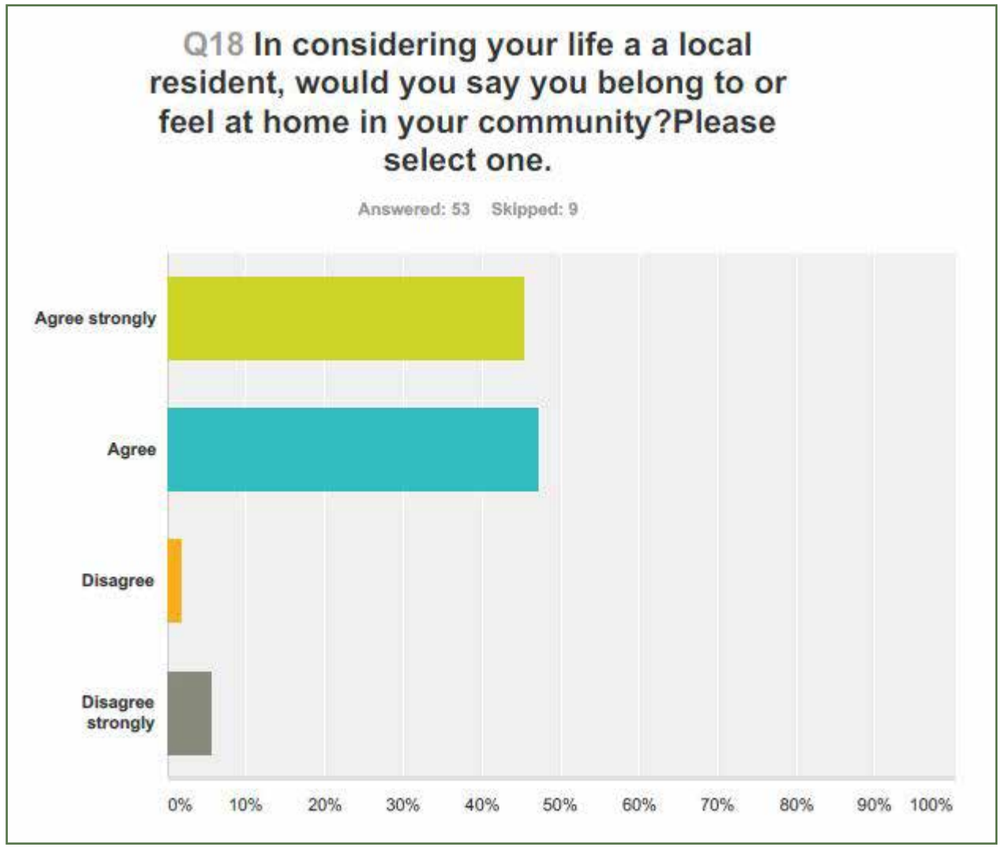


Q15 What level of tree stewardship would you or your organization be willing to do?

Answered: 47 Skipped: 15

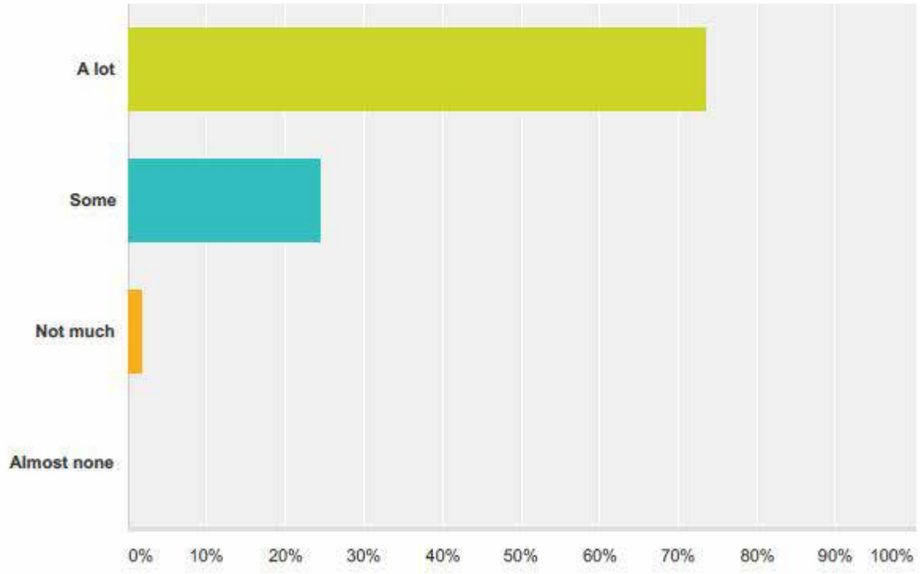



Q17 In the last 12 months, about how many times, if ever, have your done the following things?
Answered: 53 Skipped: 9
Recycled paper or container...
Composted food waste throug...
Composted yard waste throug...
Maintain a home garden
Work in a community...
0
1
2
3
4
5
6
7
8
9
10


Q18 In considering your life a a local resident, would you say you belong to or feel at home in your community?Please select one.
Answered: 53 Skipped: 9
Agree strongly
Agree
Disagree
Disagree strongly
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

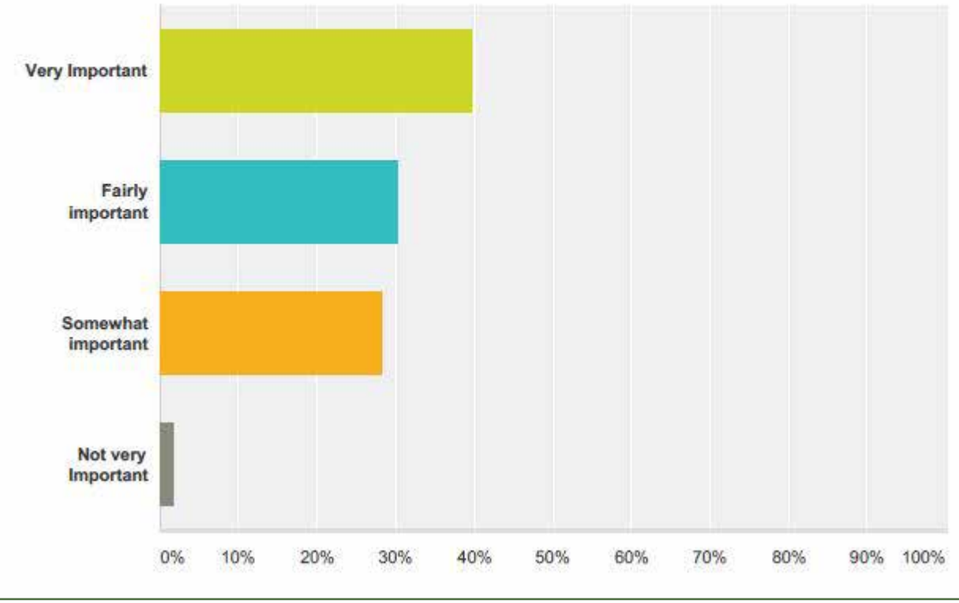
Q19 How much interest do you have in knowing what goes on in your community? Please select one.

Answered: 53 Skipped: 9



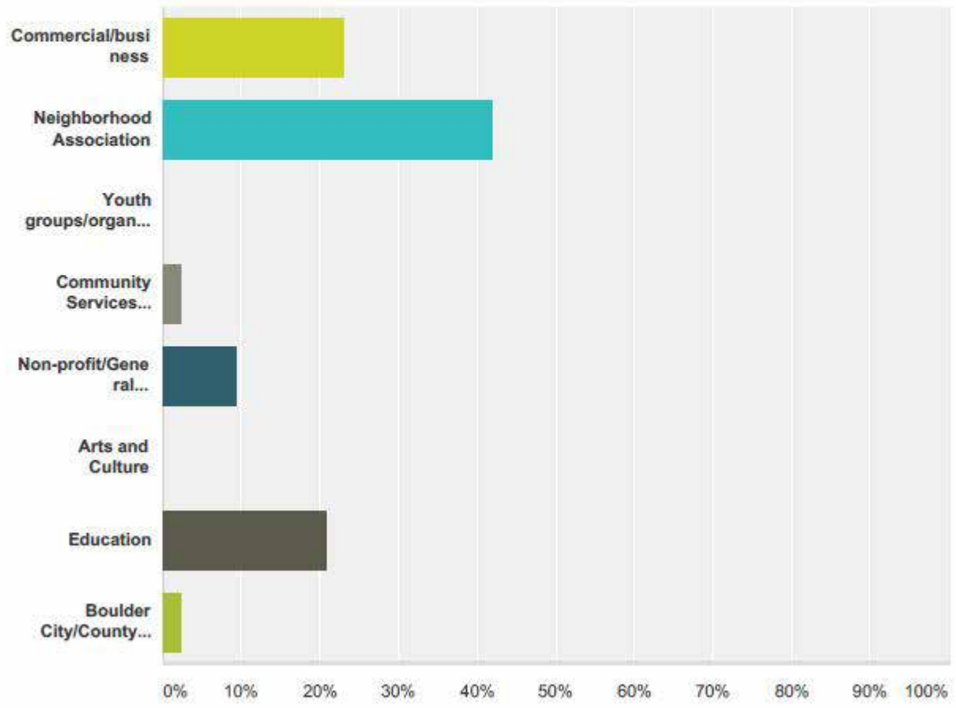
Q20 How important is it to you that you participate in local community activities? Please select one.

Answered: 53 Skipped: 9



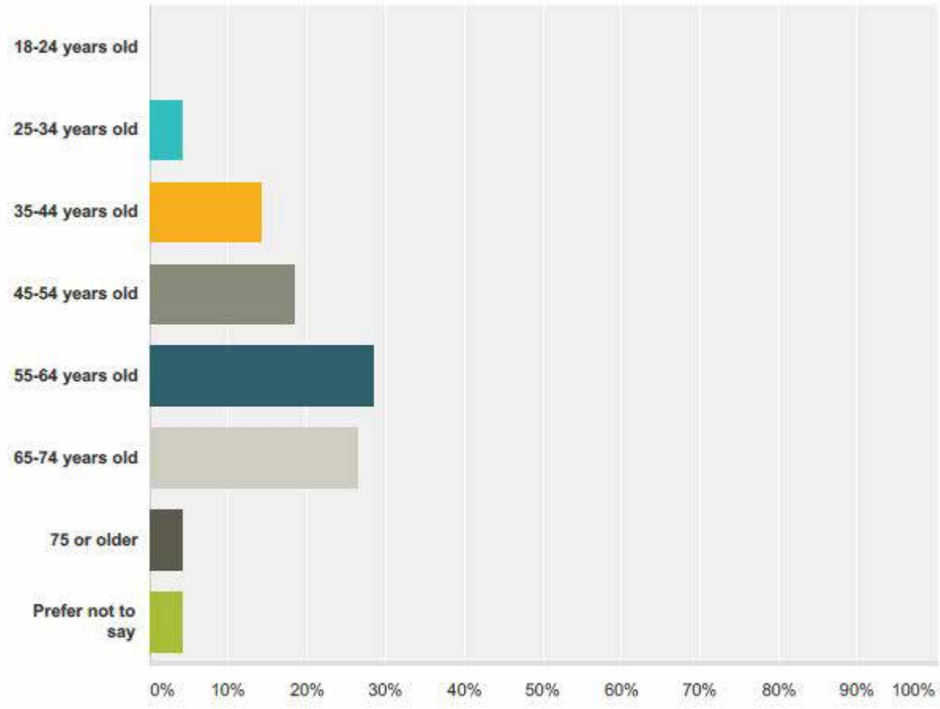
Q21 What type of organization do you work for? (please choose the organziation you were contacted through if you belong/work for multiple organizations).

Answered: 43 Skipped: 19



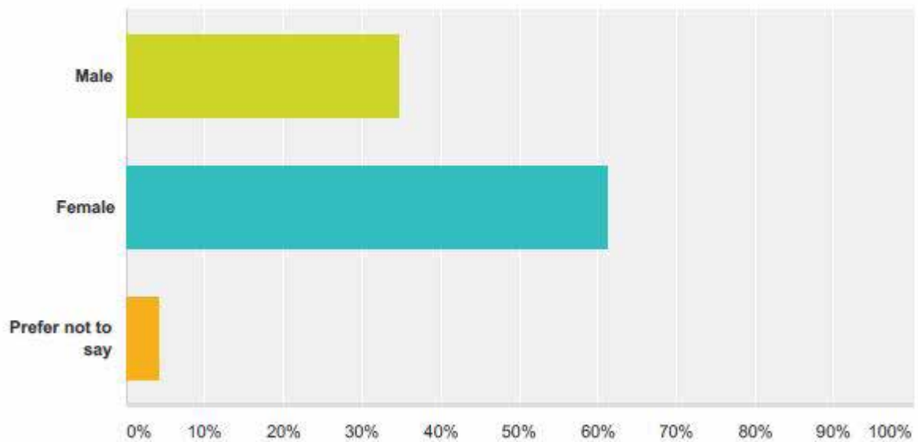
Q22 What is your age?

Answered: 49 Skipped: 13



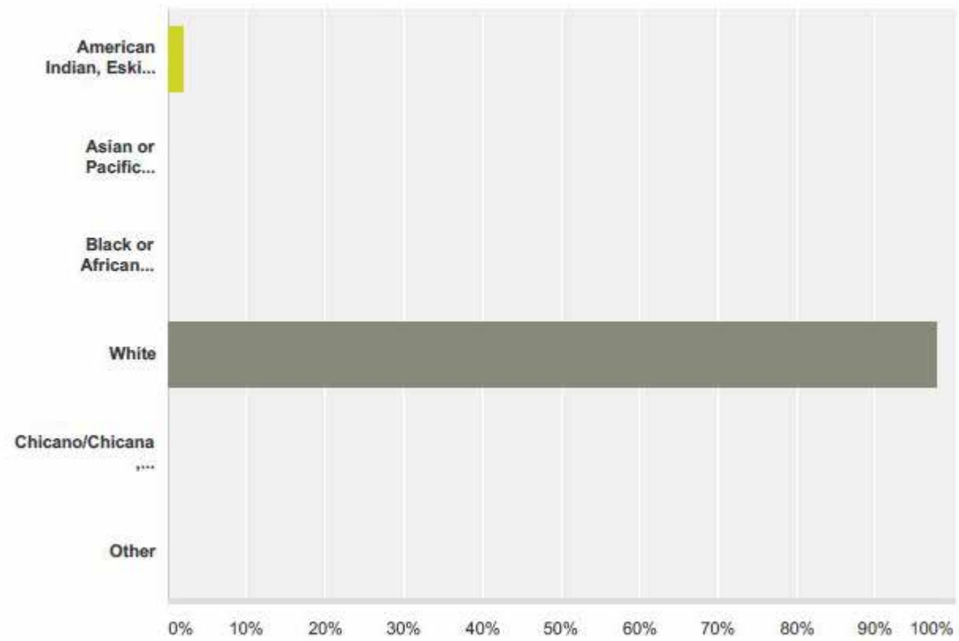
Q23 What is your gender?

Answered: 49 Skipped: 13



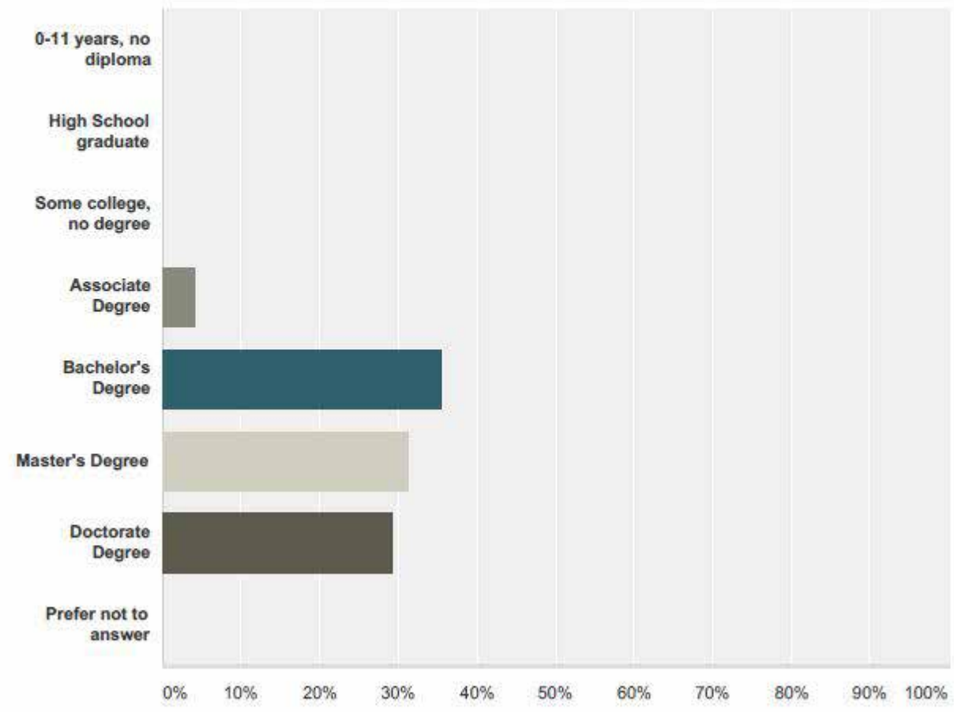
Q24 Which best describes your race?

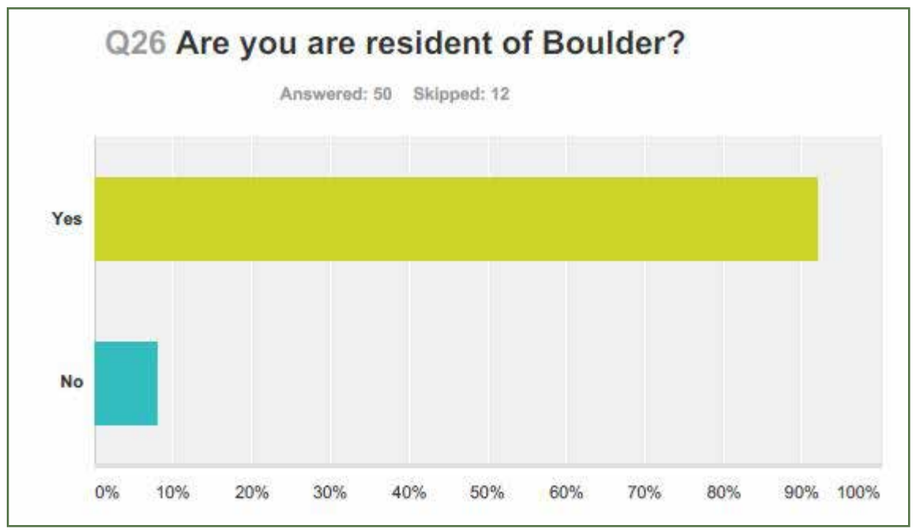
Answered: 48 Skipped: 14



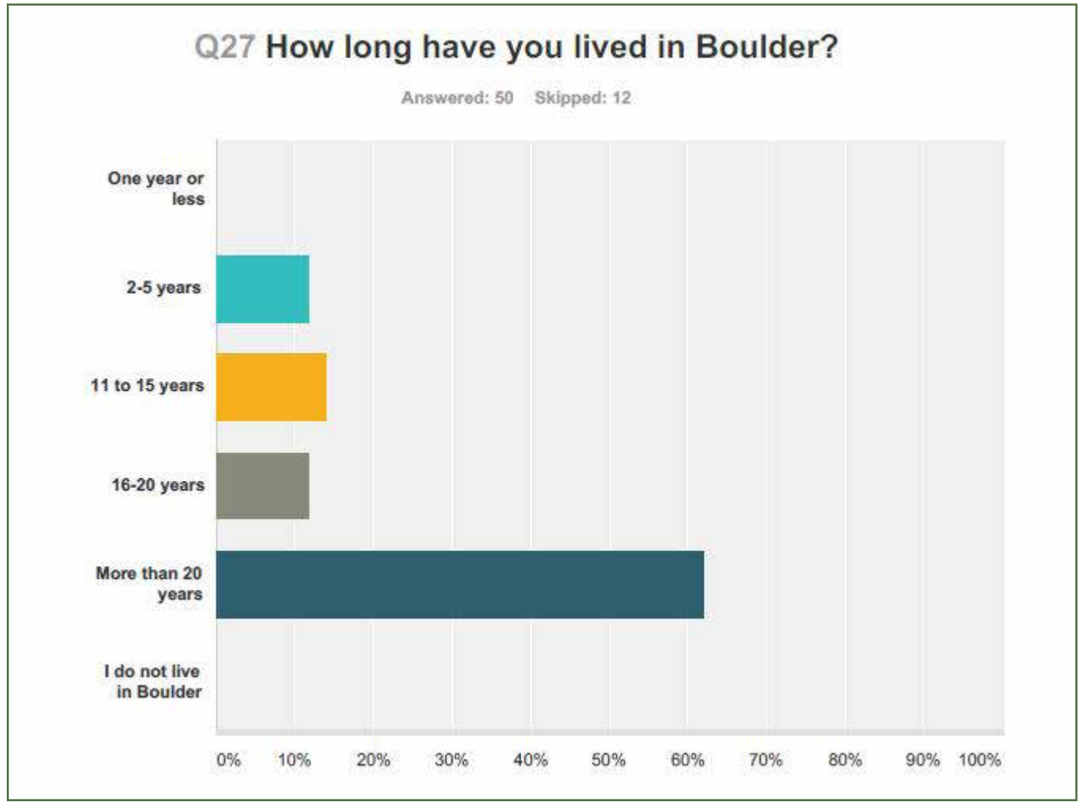
Q25 What is the highest level of education you have completed?

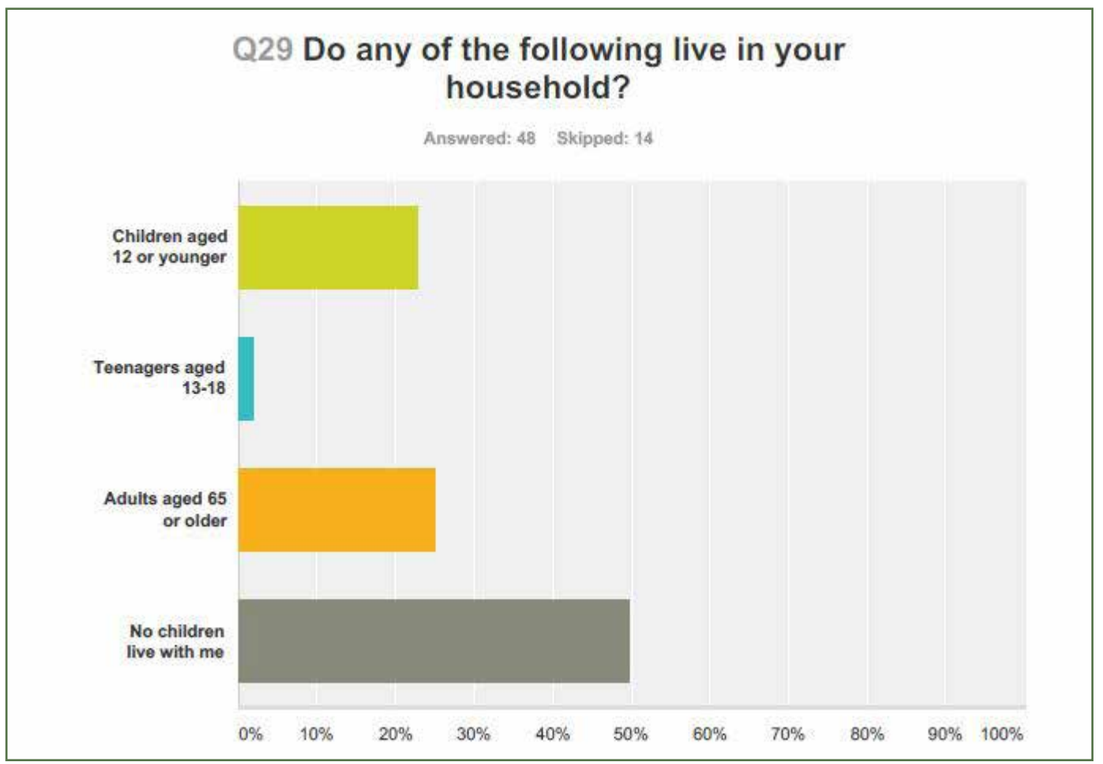
Answered: 48 Skipped: 14

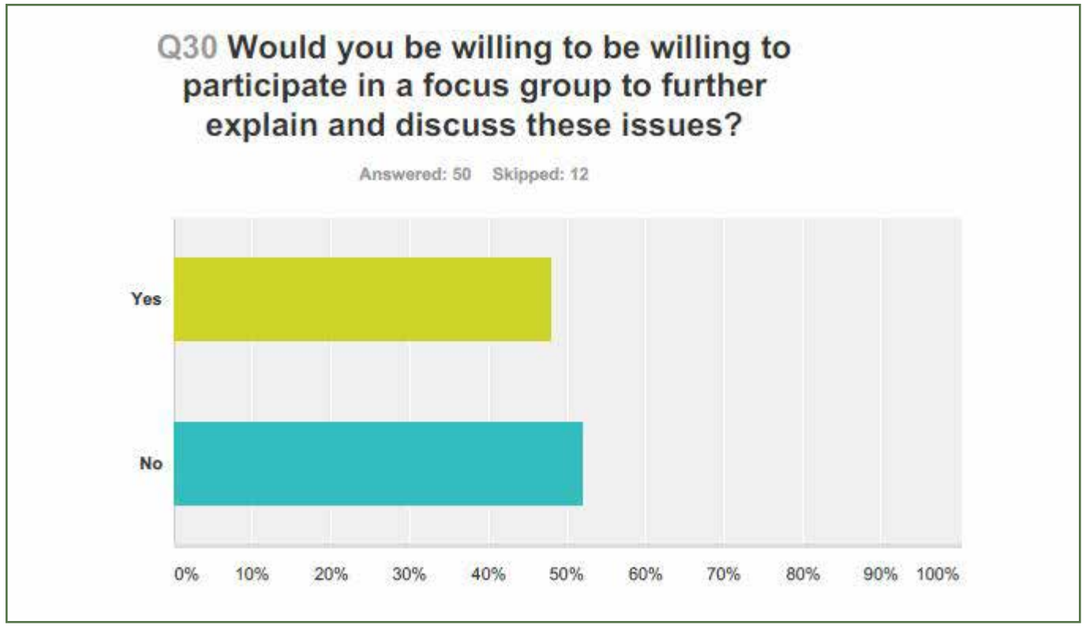



Q26 Are you are resident of Boulder?
Answered: 50 Skipped: 12
Yes
No
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%


Q28 Do you rent or own?Please select one.
Answered: 51 Skipped: 11
Rent
Own
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

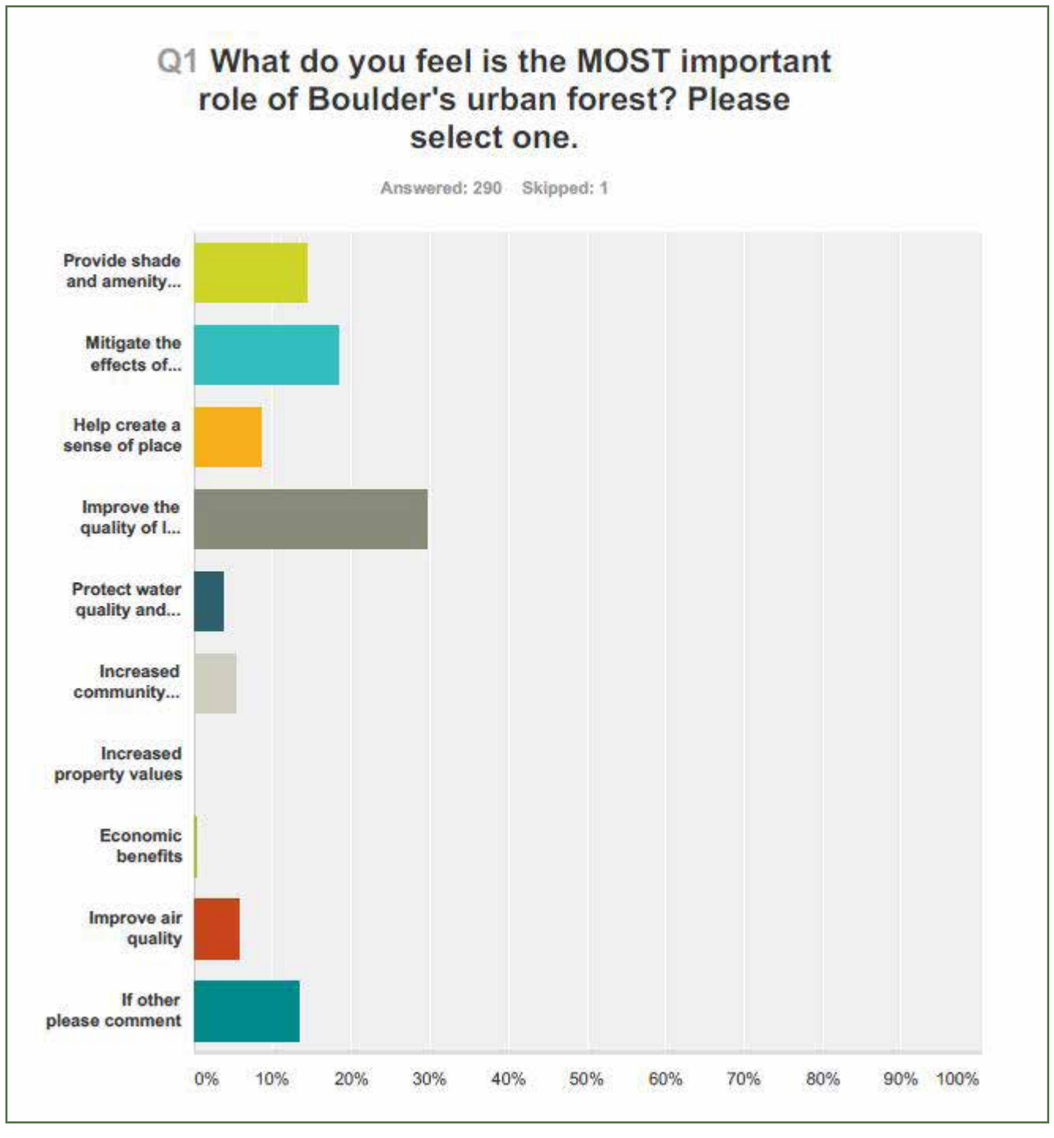

Q27 How long have you lived in Boulder?
Answered: 50 Skipped: 12
One year or less
2-5 years
11 to 15 years
16-20 years
More than 20 years
I do not live in Boulder
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

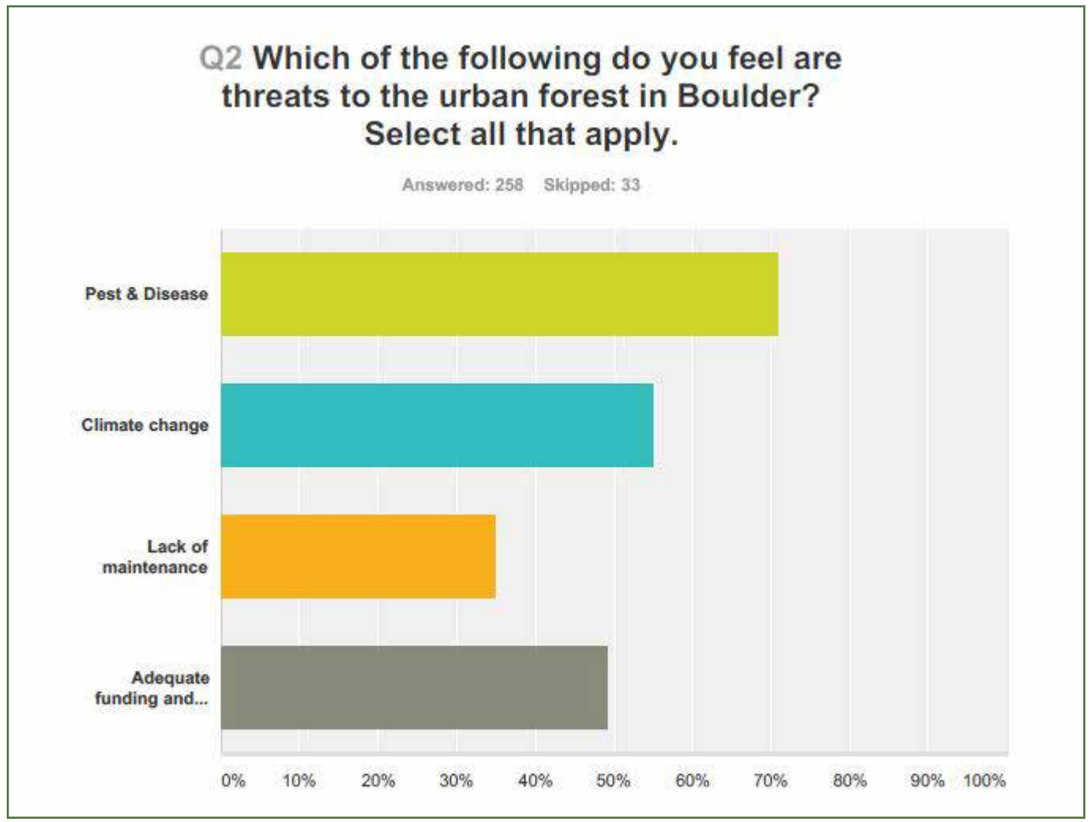

Q29 Do any of the following live in your household?
Answered: 48 Skipped: 14
Children aged 12 or younger
Teenagers aged 13-18
Adults aged 65 or older
No children live with me
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

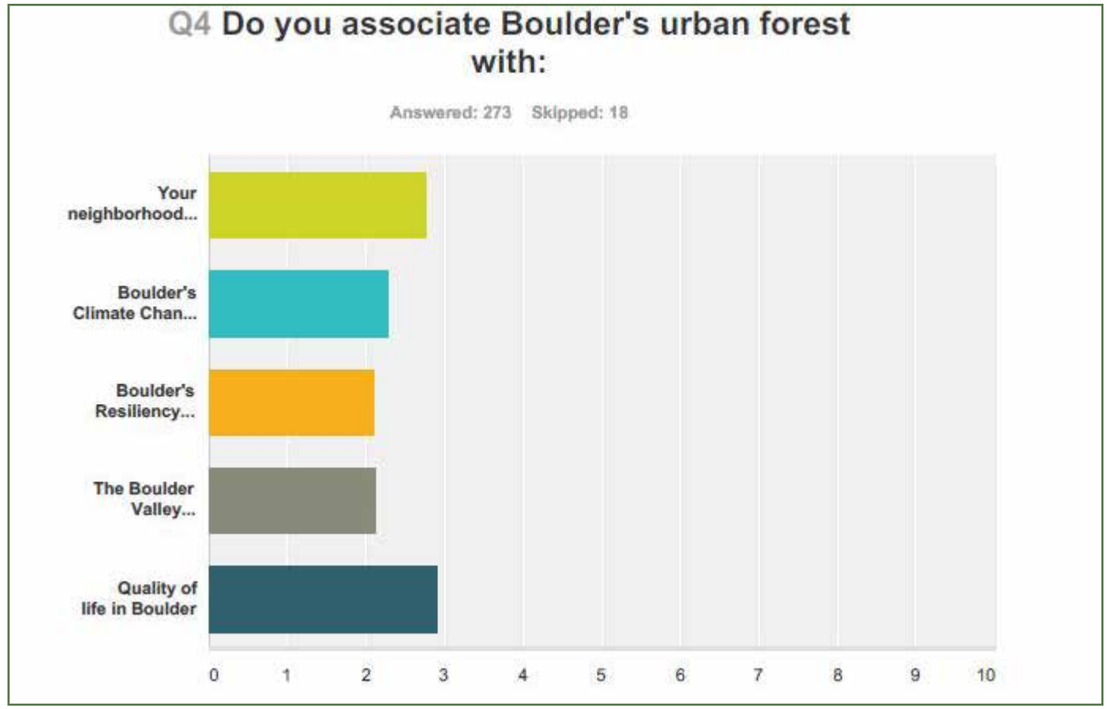


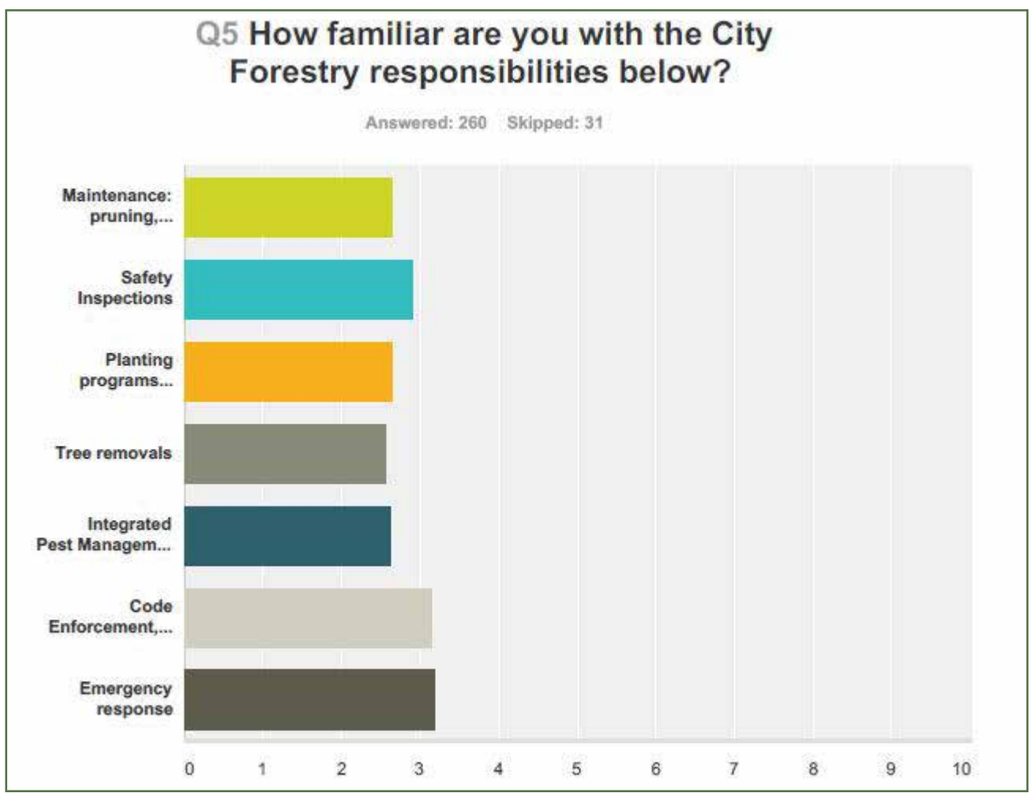
Short-Form Survey Questions

The following charts represent th responses to the 2Forks short-form survey questions. Charts were created only from questions with easily graphed responses. Some questions, such as open response questions, were not charted. Thus, some questions do not have a chart.



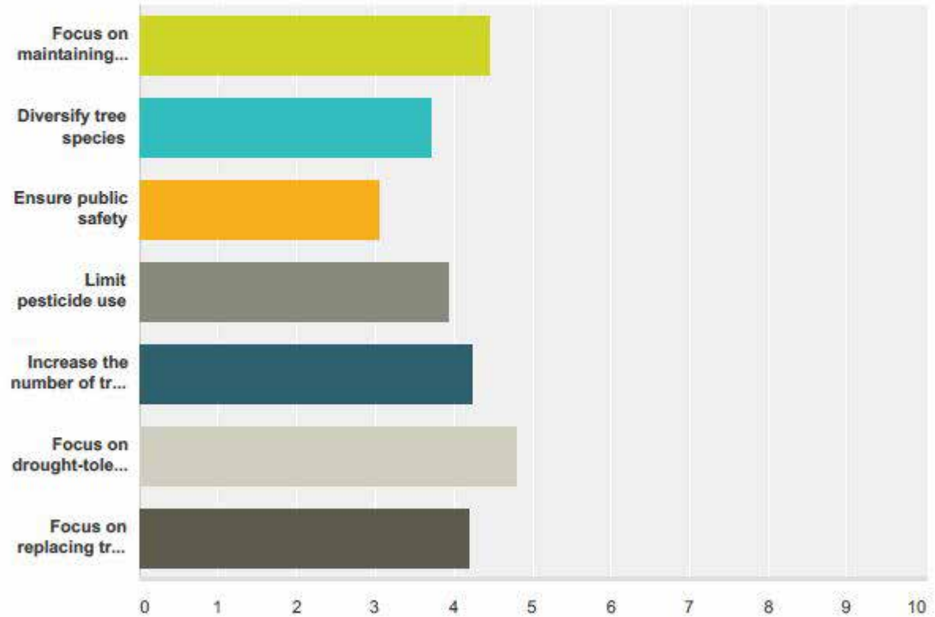

Q2 Which of the following do you feel are threats to the urban forest in Boulder? Select all that apply.
Answered: 258 Skipped: 33
Pest & Disease
Climate change
Lack of maintenance
Adequate funding and...
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Q4 Do you associate Boulder's urban forest with:
Answered: 273 Skipped: 18
Your neighborhood...
Boulder's Climate Chan...
Boulder's Resiliency...
The Boulder Valley...
Quality of life in Boulder
0
1
2
3
4
5
6
7
8
9
10


Q5 How familiar are you with the City Forestry responsibilities below?
Answered: 260 Skipped: 31
Maintenance: pruning,...
Safety Inspections
Planting programs...
Tree removals
Integrated Pest Managem...
Code Enforcement,...
Emergency response
0
1
2
3
4
5
6
7
8
9
10

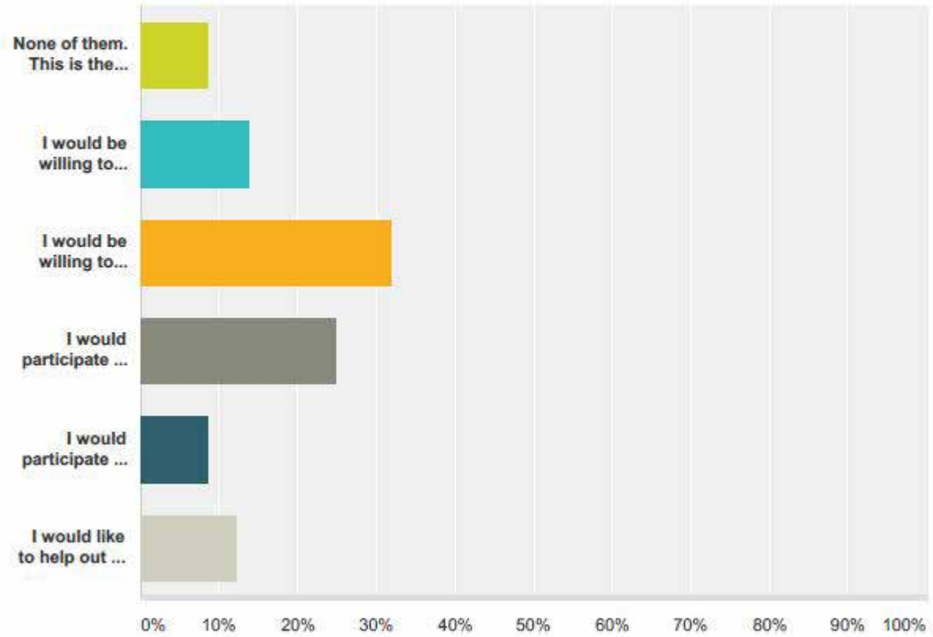
Q7 Please rate the following City Forestry goals in order of importance to you, 1 being the most important and 7 being the least.

Answered: 261 Skipped: 30



Q9 What level of tree stewardship would you or your organization be willing to do?

Answered: 210 Skipped: 81



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Dictionary

Arboriculture

- The science, art, technology, and business of tree care.

Community Urban Forest

- The collection of publicly owned trees within an urban area, including street trees and trees in parks and other public facilities.

Heritage Tree

- A large, individual tree with unique value, which is considered irreplaceable due to age, size, rarity, aesthetic, botanical, ecological, and/or historical value.

Inventoried Trees

- Includes all public trees collected in the inventory as well as trees that have since been collected by city staff.

Life-Cycle Analysis

- Life Cycle Assessment is a systematic inventory and analysis of the environmental effect that is caused by a product or process starting from the extraction of raw materials, production, use, through to the waste management.

Natural Area

- A defined area where native trees and vegetation are allowed to grow and reproduce naturally with little or no management except for control of undesirable and invasive species.

Private Tree

- A tree located on private property, including residential and commercial parcels.

Public Tree

- A tree located in the public ROW, city park, and/or city facility.

Right Tree Right Place

- The practice of installing the optimal species for a particular planting site. Considerations include existing and planned utilities and other infrastructure, planter size, soil characteristics, water needs as well as the intended role and characteristics of the species.

Significant Tree

- A healthy evergreen or deciduous tree of specific size as defined by policy and/or regulation.

Structural and Training Pruning

- Pruning to develop a sound and desirable scaffold branch structure in a tree and to reduce the likelihood of branch failure.

Tree Canopy

- The layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Tree in Proximity to Trails/Facilities

- A tree that, as the result of size and location, has the potential to impact or interfere with the use, safety, and/or condition of a defined trail, structure, or facility (e.g., picnic table, bench, parking area, etc.)

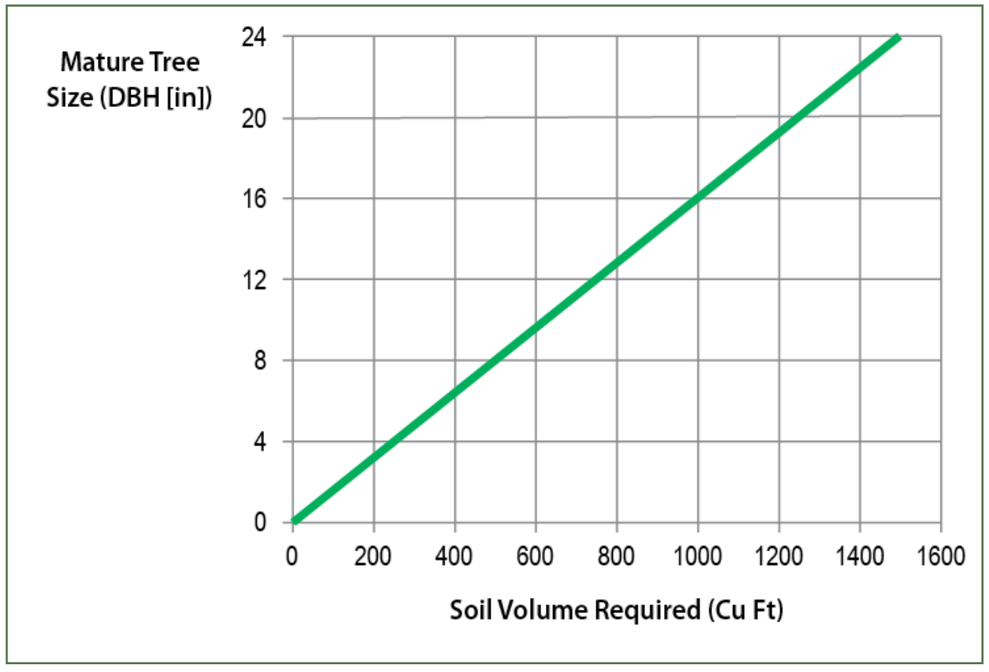
Urban Forest

- The collection of privately owned and publicly owned trees and woody shrubs that grow within an urban area.

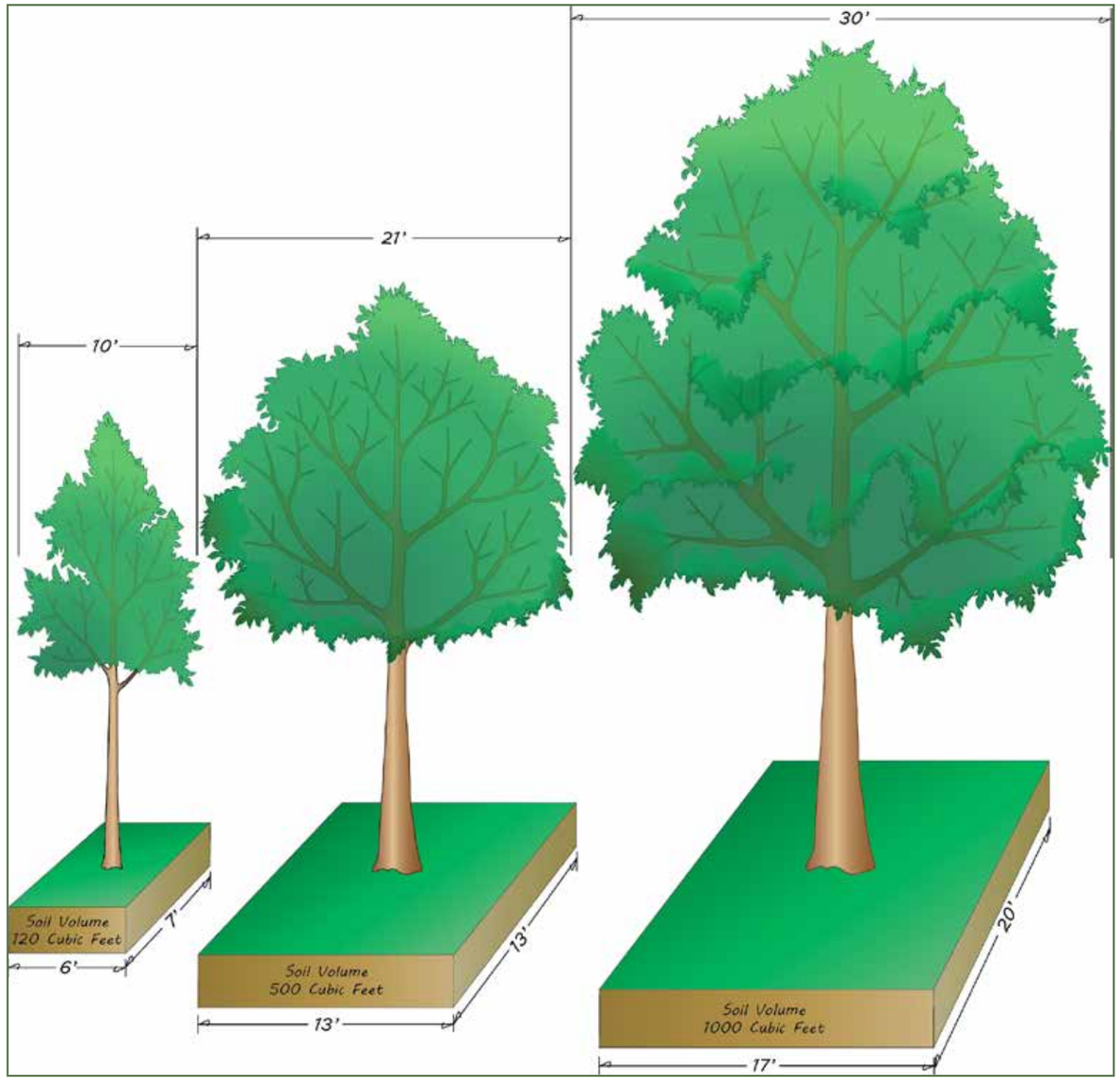
Urban Forestry

- The cultivation and management of native or introduced trees and related vegetation in urban areas for their present and potential contribution to the economic, physiological, sociological, and ecological well-being of urban society.

Soil Volume and Tree Stature

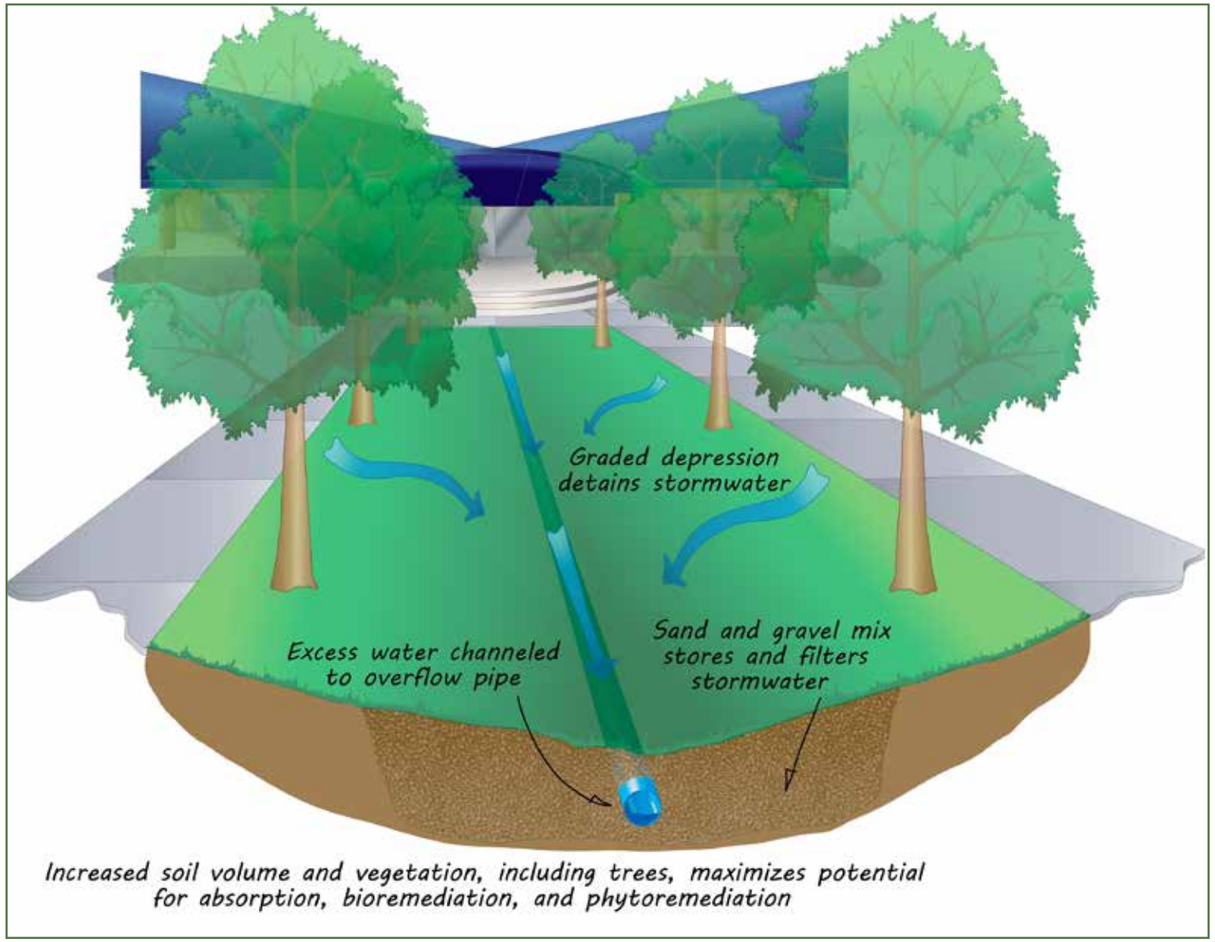


Above: General relationship between soil volume requirements and mature tree size (James Urban, various sources, 1992).

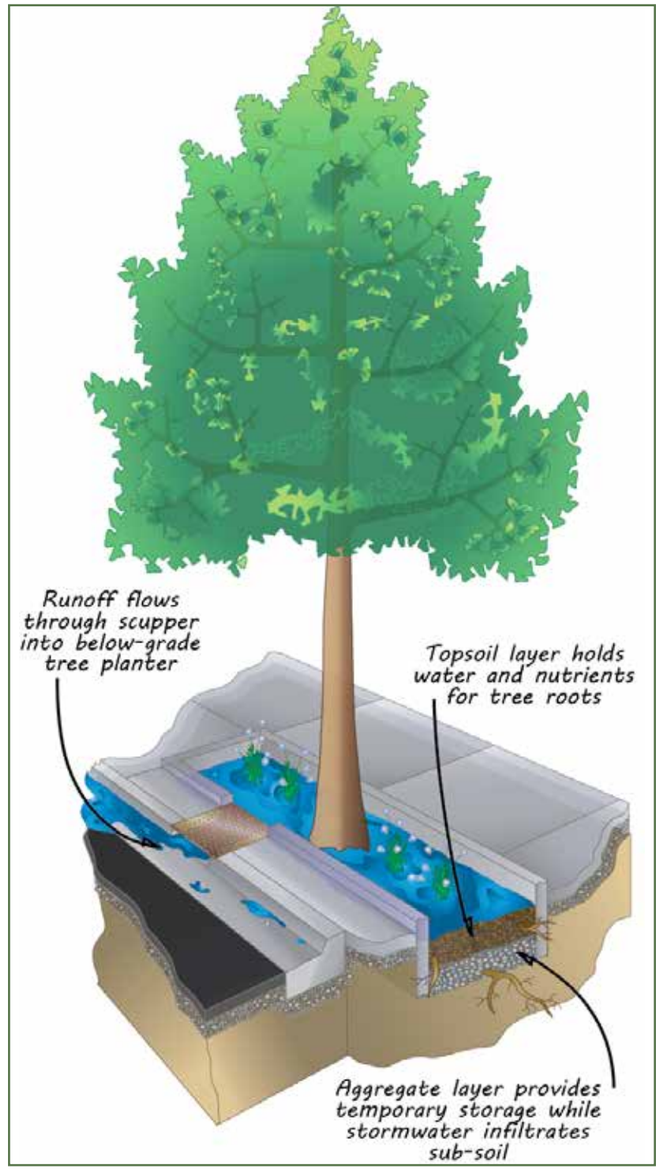


Above: Tree growth is limited by soil volume. Larger stature trees require larger volumes of uncompacted soil to reach mature size and canopy spread (Casey Trees, 2008).

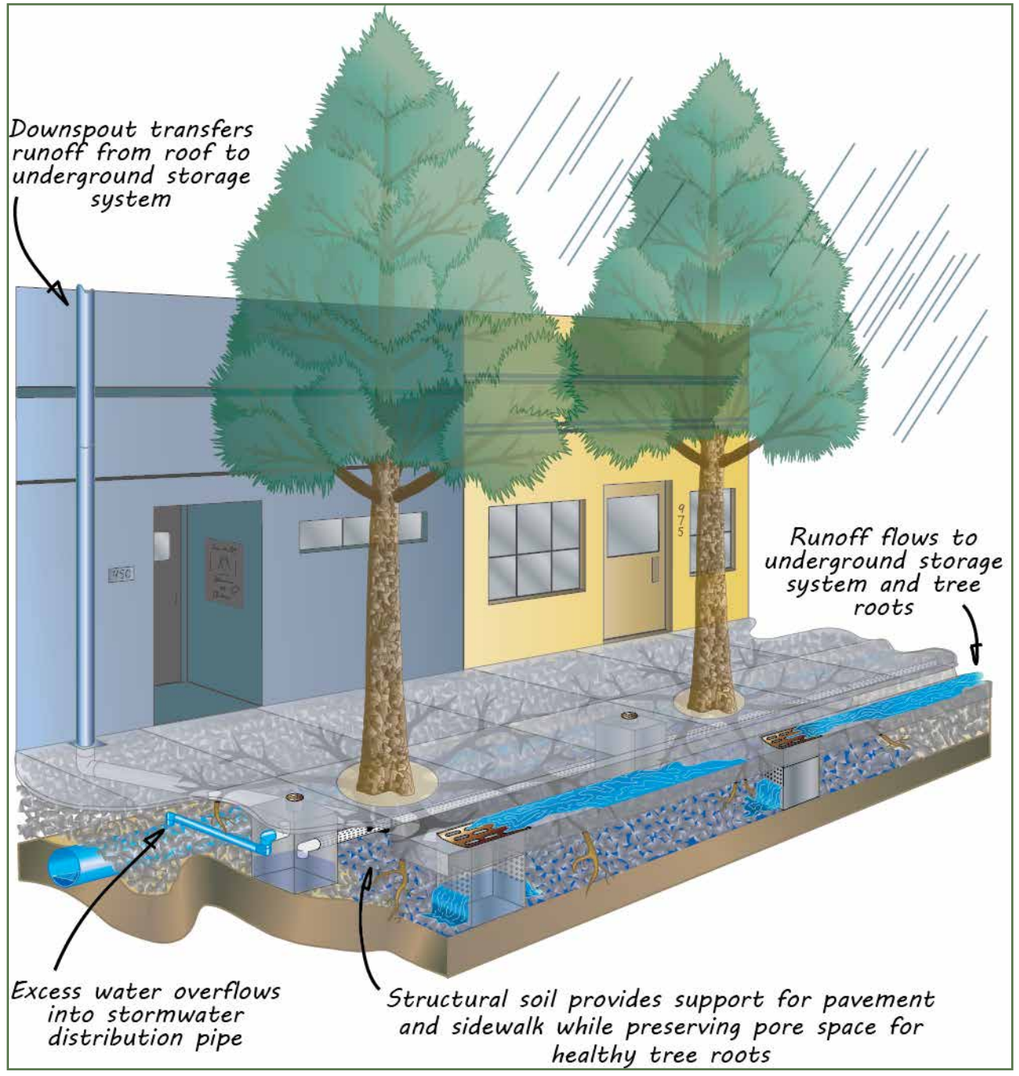
Alternative Planter Design



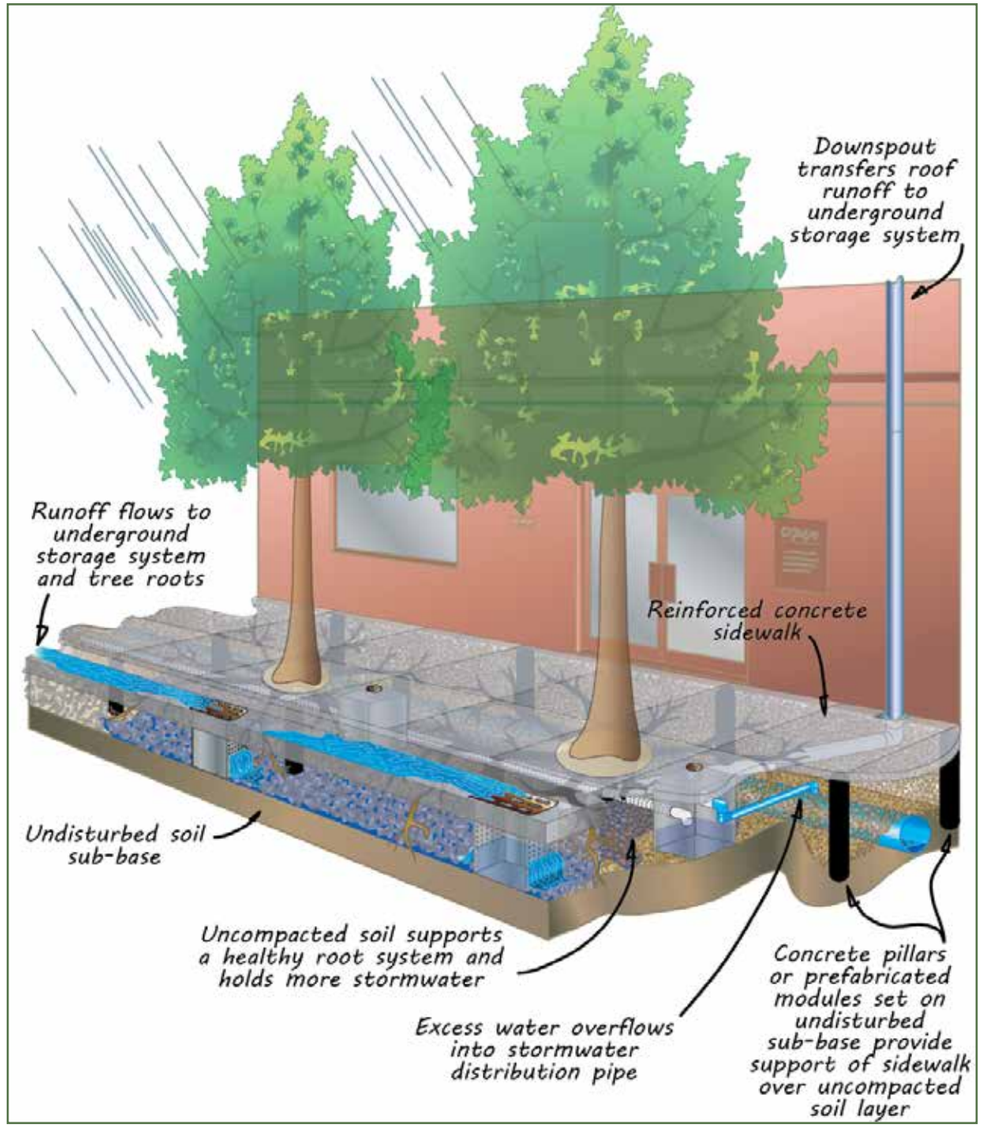
Above: Bioswales are landscaped drainage areas with gently sloped sides designed to provide temporary storage while runoff infiltrates the soil. They reduce off-site runoff and trap pollutants and silt.



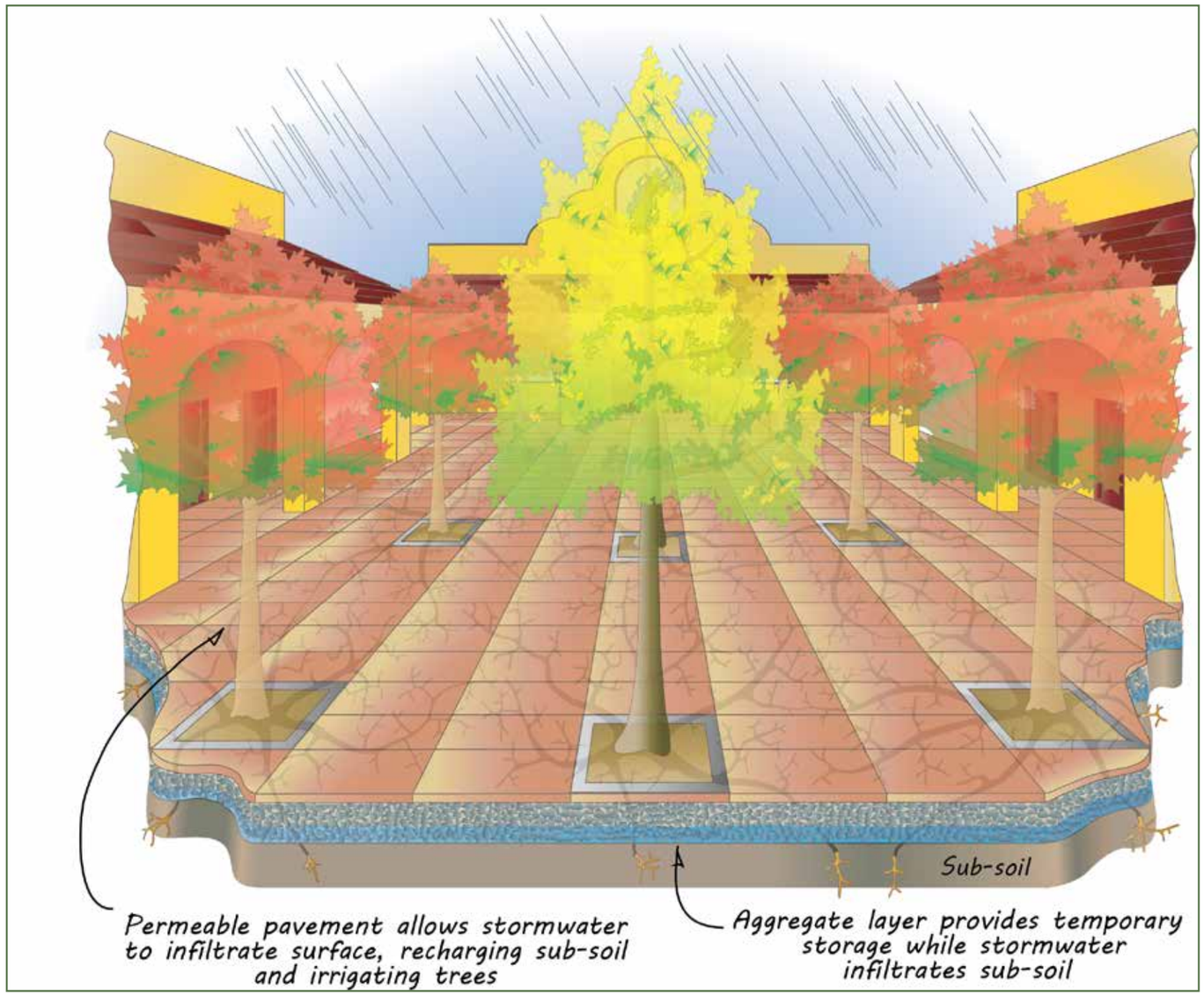
Above: Stormwater tree pits are designed to collect runoff from streets, parking lots, and other impervious areas. Stormwater is directed into scuppers that flow into below-grade planters that then allow stormwater to infiltrate soils to supplement irrigation.



Above: Structural soil is a highly porous, engineered aggregate mix, designed for use under asphalt and concrete as a load-bearing and leveling layer. The created spaces allow for water infiltration and storage, in addition to root growth.

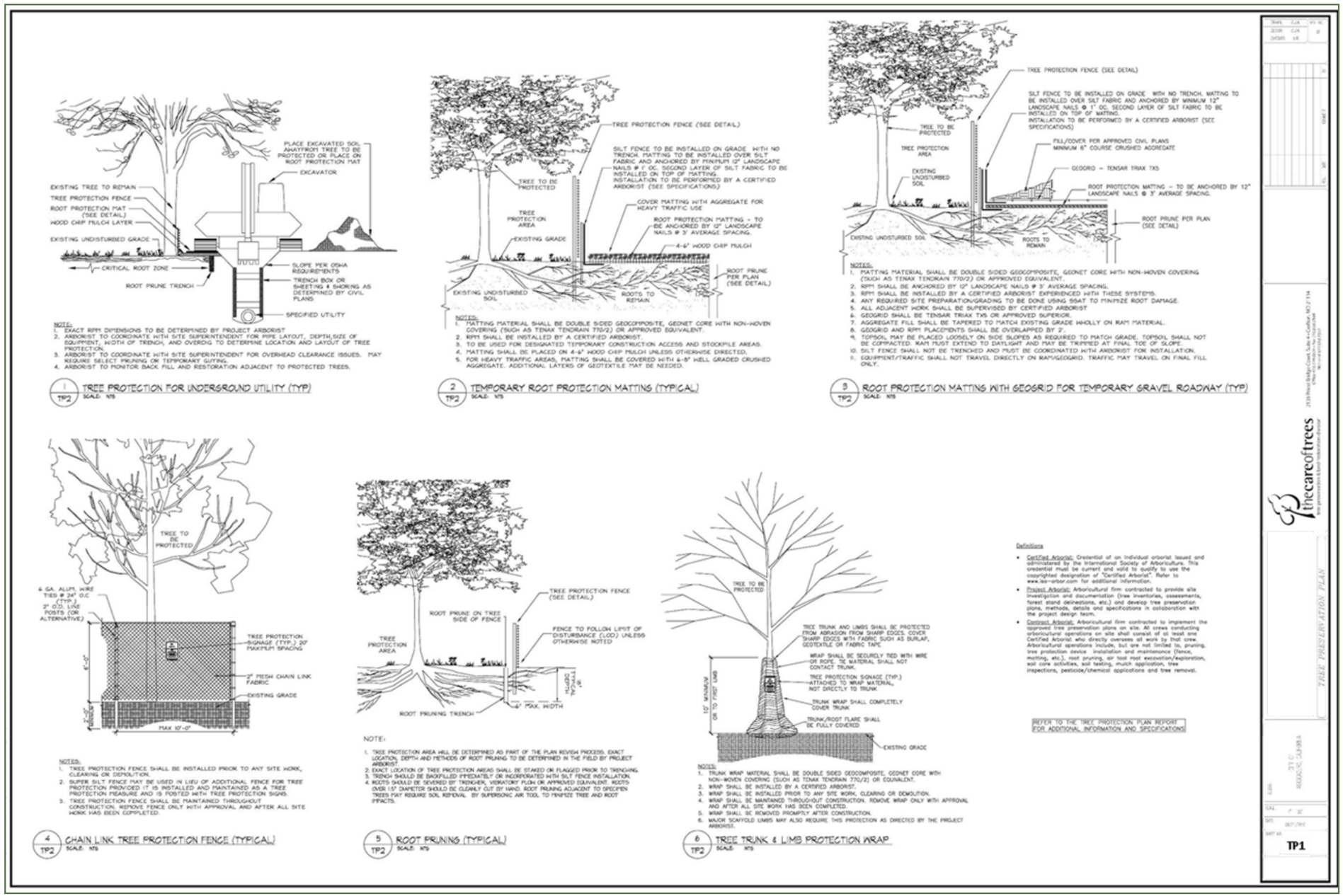


Above: Suspended sidewalks use pillars or structured cell systems to support reinforced concrete, increasing the volume of uncompacted soil in subsurface planting areas and enhancing both root growth and stormwater storage.



Above: Permeable pavements allow stormwater and oxygen to infiltrate the surface, promoting tree health and groundwater recharge.

Standard Tree Planting Detail (Placeholder)



Right: Standard Detail of Tree Protection Measures