Growth Rates of Common Urban Trees in Westminster, Colorado

Wood, K.A.; Poulson, A.M.

Abstract

This report characterizes the growth of 19 common urban tree species grown on publicly-maintained land in Westminster, CO, over the 24-year period between 1992 and 2016. The growth rates published in this report – expressed in diameter inches – can be used by property owners, landscape architects, designers/installers and tree care professionals to select urban trees that will quickly provide shade, aesthetics and other benefits after planting.

Cottonwood, catalpa, silver maple and white oak grew most quickly. Piñon and hawthorn were the slowest growers. Additional factors, such as insect and disease susceptibility, hardiness and soil preferences as discussed in this report, should also be considered when selecting species.

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COLORADO STATE FOREST SERVICE
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Introduction

In the late 1980s and early 1990s, the City of Westminster planted thousands of 2- to 2.5-inch caliper trees on publicly maintained land. In late 1992/early 1993, the city's forestry department inventoried more than 3,000 of these public trees throughout Westminster's maintained parks, city facilities, streetscapes and medians. These 3- to 12-inch diameter trees had already completed the establishment stage of their life cycles and had entered the growth stage at the time of initial measurement.

Eight years later, in 2000, then-Westminster City Forester Keith Wood recognized an opportunity to assess the growth rates of trees in Westminster's unique growing conditions by remeasuring many of the same trees. Later, as the Colorado State Forest Service's community forestry program manager, Wood continued to measure the trees at eight-year intervals. This report compiles the diameter inch measurements collected in 1992, 2000, 2008 and 2016, representing 24 years of data.

Reports were also published covering observations in 2000 and 2008; contact Keith Wood at keith.wood@colostate.edu to request a copy of those reports.

Methods

Led by Wood, staff and volunteers for the Colorado State Forest Service and the City of Westminster collected each year's measurements. In 1992, 2000 and 2008, tree data were documented on paper and entered into Excel spreadsheets; locations were recorded in terms of street names, management units (median, park, district, etc.) and cardinal directions. In 2016, the most recent measurement year, location data and diameter measurements were documented using handheld GPS devices and ArcGIS ArcPad software. View a map of tree locations in Appendix A.

Volunteers were trained on tree measurement techniques and the use of the GPS devices. Staff and volunteers collected the diameter at breast height (DBH = 4.5 feet above ground) for each tree. Trees were measured with diameter tapes, and measurements were rounded up or down to the nearest inch.

For trees on sloped ground, diameters were measured 4.5 feet up the trees' vertical centerlines. For slanted trees, measurements were taken 4.5 feet from the tree's base along the slant of the tree. For trees with codominant or multiple stems diverging below 4.5 feet, diameter measurements were collected at the narrowest point between the stem divergence and the tree base.

Sample sizes (N) varied based on tree type; low sample sizes ($N \leq 10$ trees) were removed from the study unless trees were spread over several growing sites (e.g., catalpa, piñon, red maple and white fir).

Only trees that survived the 24-year period and remained in fair, good or excellent condition are represented in this report. Severely stressed trees in poor or very poor condition were excluded to provide accurate growth estimates for healthy trees receiving adequate water.

Over the 24-year study period, more than half the trees were eliminated from the study due to insect and disease issues, insufficient irrigation (see Figure 1), development or other causes.

Figure 1: *Severely drought-stressed trees were not included in the study. Photo: CSFS*

Results

Summary

Figure 2: *The hawthorn (Crataegus spp.) ranked as the slowest growing overall. Photo: CSFS*

Overall, cottonwood, catalpa, white oak, silver maple and white ash grew most quickly in this semi-arid climate, each yielding more than 10 inches in diameter growth over the 24-year period. White fir, red maple, hackberry, piñon and hawthorn were the slowest growers, adding 7.5 inches or less.

On average, trees grew more quickly during the 1992-2000 measurement period (0.48 inch/year) than during the 2000-2008 (0.30 inch/year) or 2008-2016 (0.32 inch/year) periods. This is in line with the more vigorous growth common during earlier growth stages. Additionally, a significant drought impacted this region in the early 2000s, with irrigation and watering restrictions placed on many landscapes with above-ground irrigation systems in 2002/2003.

Total and annualized growth rates for the 24-year study period are listed by species in Table 1, ranked in descending order from fastest- to slowest-growing. Selection categories – shade, evergreen and ornamental – are included for assistance in determining the ideal species for various planting applications. Figure 3 displays trees by growth rate category.

A discussion of growth rates by selection category and consideration factors for species selection follow in the Discussion section.

Table 1: 24-Year Growth Rates of 19 Common Tree Species by Category

Species Name (N=Sample Size)	Total 24-Year Diameter Growth in Inches (1992 to 2016)	Annualized 24-Year Diameter Growth in Inches (1992 to 2016)	Category
Cottonwood (N=167)	13.57	0.57	Shade
Catalpa (N=10)	10.70	0.45	Shade
Oak, white (N=30)	10.23	0.43	Shade
Maple, silver (N=26)	10.23	0.43	Shade
Ash, white (N=17)	10.06	0.42	Shade
Spruce, blue (N=93)	9.90	0.41	Evergreen
Pine, ponderosa/Austrian (N=392)	9.57	0.40	Evergreen
Ash, green (N=211)	9.35	0.39	Shade
Linden (N=94)	9.11	0.38	Shade
Russian-olive (N=22)	8.73	0.36	Ornamental
Crabapple (N=68)	8.63	0.36	Ornamental
Oak, red (N=41)	8.54	0.36	Shade
Honeylocust (N=176)	8.41	0.35	Shade
Maple, Norway (N=56)	8.20	0.34	Shade
White fir (N=8)	7.50	0.31	Evergreen
Maple, red (N=8)	7.50	0.31	Shade
Hackberry (N=28)	7.18	0.30	Shade
Piñon (N=10)	5.90	0.25	Evergreen
Hawthorn (N=21)	5.14	0.21	Ornamental

Table 1: *24-Year Growth Rates by Category*

Figure 3: 24-Year Growth Rates of 19 Common Tree Species in Diameter Inches

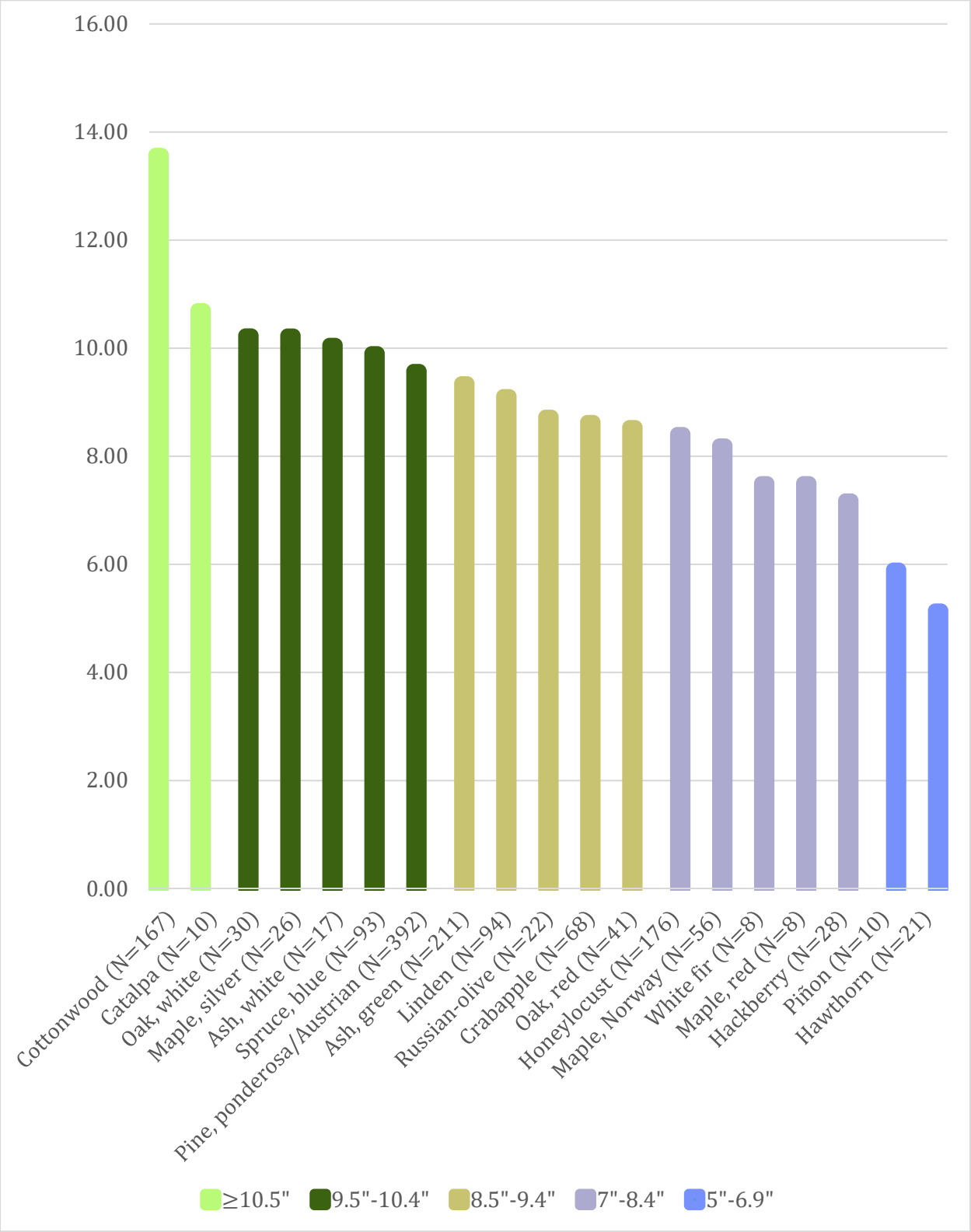

***Figure 3**: 24-Year Growth Rates in Diameter Inches*

Discussion

Local Climate

This report characterizes the growth of trees grown in the semi-arid climate, clay soil and poor overall environment of the Front Range city of Westminster, CO. Most trees planted in this setting are not native to the high plains ecosystem. It can therefore be challenging to establish and grow healthy trees in this area; however, with proper species selection, handling, planting and care, many trees can grow to their full potential.

Some tree species revealed to be fast or moderate growers in this study have previously been viewed as slow growers, and they are often passed over at planting time. However, equating growth rates with vigor can be misleading, as some of the slower-growing tree types on this list can be the most adaptable to the area (including hawthorn, hackberry and honeylocust). Adding newly discovered fast-growing species to the planting palette and incorporating hardy, slow-growing species will maximize the success of planting projects and promote species diversity.

Shade Trees

Twelve shade tree species/groups were evaluated in this study. Diameter growth ranged from 7.2 to 13.6 inches over the 24-year study period.

Cottonwoods exhibited the highest annualized diameter growth by a wide margin, at 0.6 inches per year, making good on their reputation for fast growth. The 10 catalpas measured in this study exhibited the second-fastest growth in this category, expanding diameters by an average of 0.45 inches per year.

Species Name (N=Sample Size)	Total 24-Year Diameter Growth in Inches (1992 to 2016)	Annualized 24-Year Diameter Growth in Inches (1992 to 2016)
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Maple, red (N=8)	7.50	0.31
Hackberry (N=28)	7.18	0.30

***Table 2**: 24-Year Growth Rates of Shade Trees*

The white oak group (composed mainly of bur, swamp white and English oak) claimed the No. 3 spot among shade trees. White oak species continue to exhibit moderate to fast diameter growth regardless of their reputation for slow growth.

Despite their No. 2 ranking in the previous report (covering growth from 1992-2008), silver maples fell to a No. 4 rank in this updated analysis. The slowing growth observed in this category was likely driven in part by a "delayed" chlorosis that has been observed late in the life spans of these trees. 'Autumn Blaze' maples (silver and red maple hybrids) were widely planted in this area around the

turn of the century. While they establish quickly and demonstrate above-average initial growth, they often require nutrient supplements or major soil modification later in life to maintain vigor.

White ash (composed mainly of the popular cultivated variety 'Autumn Purple') and green ash claimed the No. 5 and No. 6 spots, respectively. While ash were among the fastest-growing trees in this study, they are no longer recommended for planting because of the threat of the invasive pest emerald ash borer; see the emerald ash borer section below for more information.

Figure 4: *The slow-growing red maple (Acer rubrum). Photo: John Ruter, bugwood.org*

The linden group – dominated by the 'Greenspire' littleleaf and 'Redmond' American cultivars – claimed the No. 7 rank among shade trees in this study. At No. 8, red oaks grew more slowly than the white oak group, most likely due to their poorer performance in high pH soils. Honeylocust and Norway maple varieties were among the slowest growing in this study, but nevertheless have become very desirable shade trees over time.

The slow-growing hackberry and red maple varieties round out the shade trees covered in this study. Hackberry is notoriously slow to establish after transplanting and battles the insect-caused nipple gall most of its life, but can be a nice shade tree if given time. Red maple, often a favorite among homeowners and landscape designers, performs poorly in the Westminster area, often becoming chlorotic and suffering significant die-back due to soil and hardiness issues.

Ash Species: Fast to Grow, Fast to Die

Emerald ash borer (EAB) – a highly destructive non-native insect from Asia – infests and kills all North American true ash species (*Fraxinus spp.*) that haven't been protected by pesticides. Planting ash varieties has slowed or halted in the area since EAB was first discovered in the United States in 2002, and subsequently in Boulder, CO in 2013. Unfortunately, because of ash's previous appeal as a fast-growing, hardy, easily-established shade tree, it had already been widely planted. This was the case in Colorado, where ash now comprise an estimated 15% or more of the state's urban trees.

The rapid growth of ash trees demonstrated in this study should be a reminder to all planters not only to avoid planting new ash trees, but also to avoid selecting species solely based on growth rates. While it can be difficult to predict which tree species might become the next victims of an invasive insect or disease, it is likely that any pests that do arrive will spread more slowly and have a smaller overall impact in diversified landscapes. Overall urban forest diversity – not rapid growth – should be planters' primary focus when selecting species.

Evergreens

Of the four evergreens evaluated in this study, blue spruce grew most quickly, adding nearly 10 diameter inches over the 24-year study period. This tree often surprises those who plant it, and should be given plenty of room to mature over time.

Species Name (N=Sample Size)	Total 24-Year Diameter Growth in Inches (1992 to 2016)	Annualized 24-Year Diameter Growth in Inches (1992 to 2016)
Spruce, blue (N=93)	9.90	0.41
Pine, ponderosa/Austrian (N=392)	9.57	0.40
White fir (N=8)	7.50	0.31
Piñon (N=10)	5.90	0.25

***Table 3**: 24-Year Growth Rates of Evergreens*

Once established, the Austrian and ponderosa pines also grew quickly. Austrian pine tolerates transplanting, heavy soil types and urban conditions slightly better than the native ponderosa. However, it should be noted that pine wilt nematode has been documented in this area since 2008 and could impact growth and survival of exotic pines, including Austrian, in coming years. Also of note, ponderosa pine growth rates were evaluated separately from Austrians and determined no significant difference between the species' growth rates existed.

***Figure 5:** Colorado's state tree, the blue spruce (Picea pungens), grew most quickly in this group. Photo: CSFS*

Rounding out the evergreens, white fir and piñon grew significantly slower than other conifers studied over the 24-year period, with many white firs showing increasing decline.

Ornamentals

Leading the charge in the ornamental group is the invasive Russian-olive. Many communities, including Westminster, have adopted Russian-olive control programs and its listing on the noxious weed list in Colorado has prevented its availability.

Species Name (N=Sample Size)	Total 24-Year Diameter Growth in Inches (1992 to 2016)	Annualized 24-Year Diameter Growth in Inches (1992 to 2016)
Russian-olive (N=22)	8.73	0.36
Crabapple (N=68)	8.63	0.36
Hawthorn (N=21)	5.14	0.21

***Table 4:** 24-Year Growth Rates of Ornamentals*

The crabapple varieties studied show the next-highest growth rate among ornamentals; hawthorn varieties, the most sluggish in this category, grew significantly more slowly.

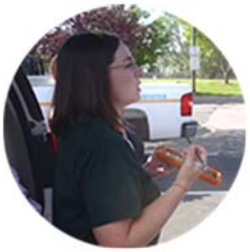
Acknowledgements

Keith Wood, Community Forestry Program Manager for the Colorado State Forest Service (CSFS), was the principal investigator for this study and lead author of this report.

Westminster City Forester John Kasza and his crew assisted in tree location and measurement. Kasza also assisted CSFS volunteers with tree identification and proper measurement techniques.

Pete Barry, CSFS Geographic Information Systems Technician, provided equipment, technical training and analysis oversight.

Nancy Dadisman, Volunteer Program Coordinator for the CSFS, coordinated volunteers for the project, took photographs and performed tree measurement.

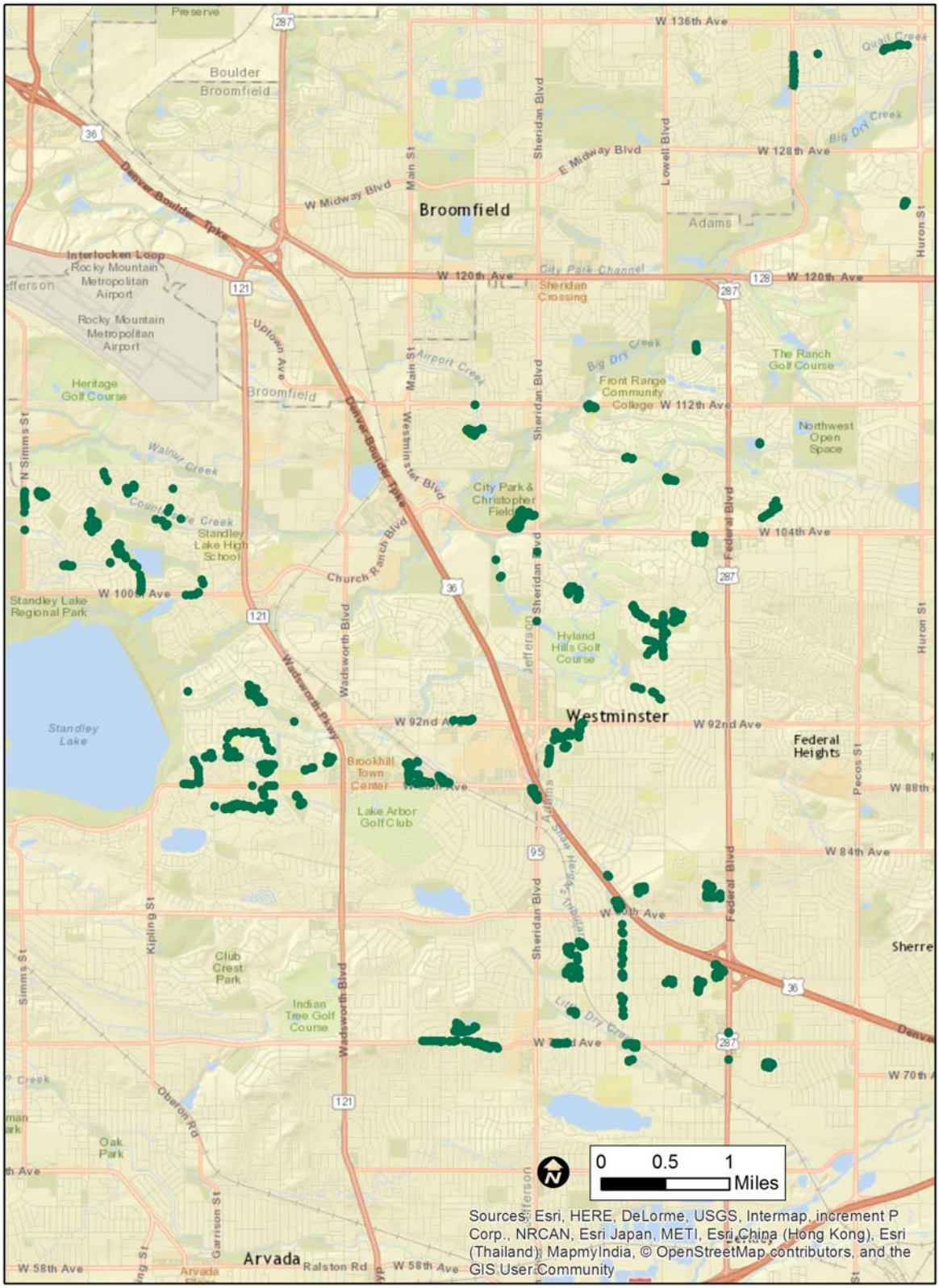


As a CSFS employee, Angela Poulson performed tree measurement, volunteer coordination and GIS data analysis. Poulson also designed and co-authored this report as an independent consultant.

The Colorado State Forest Service and the City of Westminster contributed to this study.

Colorado State Forest Service
Colorado State University
5060 Campus Delivery
Fort Collins, CO 80523-5060
(970) 491-6303
www.csfs.colostate.edu

Appendix A: Tree Locations



Appendix B: Tree Scientific Names

Ash, green	*Fraxinus pennsylvanica 'Summit', 'Marshall's Seedless', 'Patmore'*
Ash, white	*Fraxinus americana 'Autumn purple'*
Catalpa	*Catalpa speciosa*
Cottonwood	*Populus spp.*
Crabapple	*Malus spp.*
Hackberry	*Celtis occidentalis*
Hawthorn	*Crataegus spp.*
Honeylocust	*Gleditsia triacanthos*
Linden	*Tilia americana 'Redmond', Tilia cordata 'Greenspire'*
Maple, Norway	*Acer platanoides*
Maple, red	*Acer rubrum*
Maple, silver	*Acer saccharinum*
Oak, red	*Quercus rubra*
Oak, white	*Quercus robur, Q. bicolor, Q. macrocarpa*
Pine, ponderosa/Austrian	*Pinus ponderosa, P. nigra*
Piñon	*Pinus edulis*
Russian-olive	*Elaeagnus angustifolia*
Spruce, blue	*Picea pungens*
White fir	*Abies concolor*

Appendix C: Additional Resources

Nonlocal sources of tree suitability information can sometimes fail to take local climate and soil conditions into account, resulting in mass plantings of nonadaptable species and the creation of monocultures, putting local urban forests at risk of invasive species. Tree planters should rely instead on local information including this report, The Front Range Tree Recommendation List and The Colorado Ash Tree Replacement Selection Tool.