PLANT-IT 2020
INSTITUTE FOR ENVIRONMENTAL SOLUTIONS

THE SECRET LIFE OF TREES

PLANTING THE RIGHT TREE
IN THE RIGHT PLACE FOR
ENVIRONMENTAL IMPROVEMENT
IN COLORADO'S FRONT RANGE

SCIENTIFIC SOLUTIONS
FOR A BETTER ENVIRONMENT

THE CASE FOR STRATEGIC TREE PLANTING

DO TREES BELONG ON THE FRONT RANGE?

The diversity and range of trees on the Front Range of Colorado were naturally quite limited. By some estimates, only 58 species shaded Colorado before settlers began introducing nonnative trees. However, with the expansion of cities and the buildings, concrete and dense human populations that comprise them, the environmental and human health benefits trees provide have become more and more important. For example, the urban heat island effect – the increase in ambient air temperature above urban areas – can be reduced 0.04 to 0.2 °C for every one percent increase in tree canopy cover. This is just one example of the many environmental and human health benefits of the urban forest.

WHY PLANT STRATEGICALLY?

There are complex environmental tradeoffs associated with planting and maintaining trees that should be considered before you select, site and plant a tree. Some of the impacts that can result from tree planting without consideration of the environmental tradeoffs are:

- Increased ground-level ozone (smog) from high volatile organic compound (VOC)-emitting trees in nitrogen oxide (NO_X)-limited urban areas.
- Increased energy costs from improper placement or improper species selection. For example, trees that shade south-facing windows may cause increased home energy use for heating in winter.
- Increased water consumption through improper species selection.

Planted with care and forethought, the urban forest can provide multiple human health and environmental benefits. Take the time to learn about the impact your trees can have and how you can optimize the benefits of the urban forest.

THE MANY FUNCTIONS OF TREES

Trees impact the environment in many ways. The urban forest in particular has the potential to affect (both positively and negatively):

- Air quality
- Carbon storage and sequestration
- Energy conservation
- Water conservation
- Stormwater management

These impacts of urban forests can make it more or less difficult to achieve your environmental goals. To make the urban forest work for you, trees must be selected and maintained strategically.

In this booklet, you will find information regarding some of the environmental tradeoffs inherent in urban forestry. You will also find recommendations on tree species selection, placement and maintenance.

When you decide to plant a tree, keep in mind that growing healthy, long-lived trees is the key to optimizing environmental benefits, and diversity is important to maintaining the health of the entire urban forest. If you plant more than one tree, choose a variety of recommended tree species so that the urban forest will be more resistant to disease.

AIR QUALITY TRADEOFFS

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape and ecosystem processes, and reduced visibility. Urban vegetation can directly and indirectly affect local and regional air quality by altering the atmosphere through:

- Temperature moderation
- Air pollution removal
- Summer power plant emissions reduction
- Winter heating emissions increase
- Maintenance emissions
- Biogenic volatile organic compounds (BVOC) emissions

Trees reduce ambient air temperature by transferring water from the ground to the air. This can reduce the need to use energy for cooling. When correctly located, trees can also reduce the energy used for heating and cooling buildings by shading windows in the summer and blocking wind in the winter. Less energy used in buildings means reduced air pollutant emissions from power plants. Trees that shade parking spaces can reduce evaporative emissions from cars. Trees also improve air quality by directly removing particulate matter pollutants from the air by intercepting them on leaf surfaces and absorbing gaseous pollutants (ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide).

Trees may be a detriment to air quality if they shade buildings in the winter, causing an increase in heating emissions. Trees also add to air pollution if they are maintained with pollutant-emitting equipment, and through the emission of volatile organic compounds (VOC), which can contribute to ground-level ozone formation when combined with sunlight and nitrogen oxides.

TREES AND OZONE AIR POLLUTION

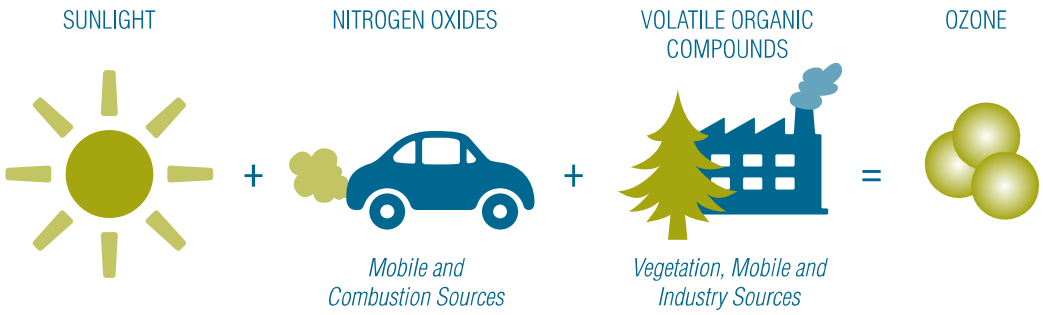
The relationship between trees and ozone air pollution is complex. In general, trees have the potential to impact ground-level ozone in three ways:

- Some trees emit BVOCs, precursors to ozone
- Some trees destroy ozone directly
- Some trees moderate temperature, which can reduce ozone formation

As the diagram below shows, ozone (O_3) is formed when nitrogen oxides (NO_X) react with VOCs, including BVOCs from trees, in the presence of sunlight. The biggest sources of VOCs in Colorado include trees and other vegetation, motor vehicles, commercial and industrial processes. NO_X is a product of combustion and has many sources, including motor vehicle emissions and all fossil fuel combustion processes, including electricity generation.

GROUND LEVEL OZONE FORMATION

SUNLIGHT + NO_X + VOCs = O_3



Though BVOC emissions from trees can contribute to ozone formation, overall an increase in tree cover generally leads to reduced ozone formation. This is partly because ozone production is temperature-sensitive. Trees that cool the air in cities are reducing ozone formation. The opposite is also true: when the urban forest is destroyed, temperatures tend to rise and ozone formation can increase.

Trees also destroy ozone directly by absorbing the gas into leaves. In the City of Golden, the urban forest destroys nine tons of ozone every year.

The amount of BVOC released by trees varies by species. High BVOC emitters release as much as four times the amount released by low emitters. Ozone air pollution is a critical issue for Colorado, so make sure to check the recommended tree species list for air quality.

WATER USE TRADEOFFS

Trees need water to grow, but urban trees may also help to conserve water. Urban trees can conserve water by shading buildings and moderating air temperature, thereby reducing the demand for electricity used in air conditioning. Electricity production accounts for 39% of freshwater use in the United States, second only to irrigation. Colorado uses 138 million gallons per day in thermoelectric power production. The volume of water that can be conserved through reduced electricity demand from tree shading could be much greater than the amount of water used by trees.

Whether or not your tree is a water conserver or a water consumer largely depends on its species, size, health and location relative to buildings. Different tree species need different amounts of water to thrive, so it is important to consider the recommended species for Colorado as well as the water availability at your site. You can maximize the efficiency with which your trees use water by planting and maintaining them correctly.

STORMWATER TRADEOFFS

Trees can function as natural stormwater management tools. Planted strategically, trees can play an important role in reducing and cleaning up runoff because of their ability to increase both infiltration (the rate at which water enters the ground) and filtration (the process of removing pollutants from the water).

Above ground, trees catch precipitation on leaves, branches, and trunks, slowing movement to the ground, and preventing rapid runoff. Trees also intercept and trap wind-blown dust before it enters streams and lakes. The leaves, stems, and trunks of trees absorb a small portion of precipitation. Some of the intercepted precipitation is evaporated back into the atmosphere.

On the ground, fallen leaves and other organic material act like sponges, holding precipitation in place, slowly releasing water into the soil, and preventing surface runoff. Roots and trunks of mature trees create hollows on the ground that hold and reduce runoff, preventing erosion.

Trees also help manage stormwater below the ground. Tree roots, leaves, and other organic matter create spaces in the soil, increasing infiltration of precipitation. Organic tree matter increases the capability of soil to hold moisture and deep roots improve the transfer of water from upper soils into lower soil levels.

ANNUAL STORMWATER MANAGEMENT VALUE OF GOLDEN'S *STREET* TREES: $56,000

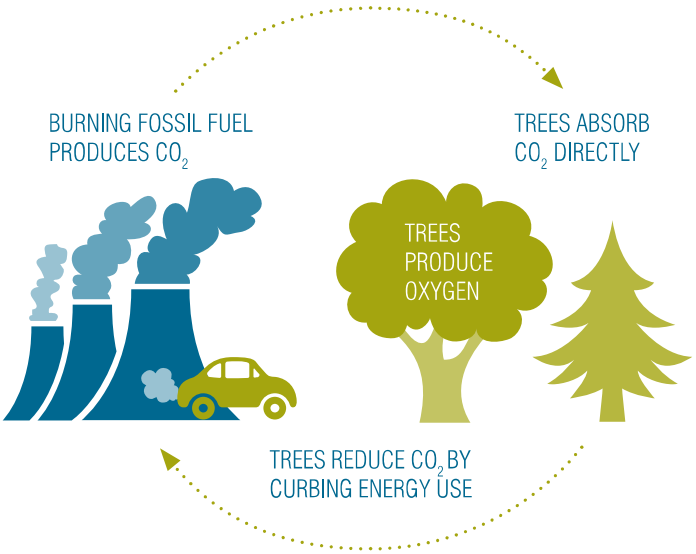
Water that does run off of forested areas is cleaner than it would be otherwise. Tree roots are natural pollution filters, taking up and processing pollutants such as nitrogen, phosphorus, and potassium through the soil and water.

Decreasing runoff volume and pollution has the potential to save millions in downstream infrastructure cost. Typical urban development often leads to stream degradation that requires costly mechanical remediation, like bank stabilization. Also, the more polluted the runoff, the more expensive the treatment process.

You can help manage stormwater runoff by reducing the area of impermeable surface on your property (like asphalt driveways and concrete walkways) and by incorporating trees into your landscape.

CARBON TRADEOFFS

Trees remove carbon dioxide from the air. As trees "breathe", they absorb carbon dioxide and release oxygen through their leaves. The amount of carbon dioxide (CO_2) absorbed annually by a tree varies from 35 to 800 pounds depending on tree species, age, and size. Trees can also help reduce CO_2 emissions from power plants by shading buildings and moderating air temperature, which may result in energy conservation.



Trees can contribute to the release of carbon back into the atmosphere: burning wood leads to large amounts of released CO_2, dead or dying trees naturally emit carbon as they decay, and tree maintenance calls for the use of CO_2 emitting machinery such as chippers, chain saws, and trucks.

To optimize the carbon sequestration function of the urban forest it is important to grow healthy and long-lived species and to maintain trees strategically.

ANNUAL CARBON SEQUESTRATION VALUE OF GOLDEN'S TREES

- Annual net carbon sequestration of Golden's forest: 500 tons
- Carbon stored by Golden's forest: 16,400 tons
- Average net carbon sequestration and storage value of a tree in Golden: $1,250

THE FACTS ABOUT TREES AND CLIMATE CHANGE

Climate change is an issue of global concern. Trees can be part of the solution.Trees sequester carbon dioxide from the atmosphere and store it in their trunks, branches, roots, and leaves. Some is released back into the atmosphere as trees grow. More is released when leaves drop and decay. When trees die, most of the carbon dioxide they sequestered in their lifetime ends up back in the atmosphere.

Despite the flow of carbon into and out of trees, in many instances natural and urban forests sequester more carbon than they emit. In places like Colorado's Front Range, urban trees are often planted in spaces where there were no trees or where trees were cleared away. Planting and maintaining an urban forest over the long-term (with a commitment to replacing dead trees) means more carbon sequestered and stored compared to keeping the space treeless. When trees die and are removed, you can prevent carbon from being immediately released back into the atmosphere by devoting the fiber to long-term uses such as construction material. If tree material is burned, it can be used to heat living spaces, offsetting the greenhouse gases produced by other sources of heat. Also, when you plant and maintain trees, some of the sequestered carbon is stored in soils.

ENERGY TRADEOFFS

Trees work to reduce the need for air conditioning in the summer in two ways: by shading your home and by reducing the outside air temperature. However, some trees may increase your heating needs by shading your home from the warming winter sun. Therefore, it is important to select the right tree and plant it in the right place, to see the best savings on both your heating and cooling bills.

The table below shows the impact of trees on energy consumption for heating and cooling, annual energy cost, and carbon dioxide emissions for a typical single-family house in Golden. The situation there is common throughout Colorado: if trees are not selected and located carefully to save energy, they might provide shade in summer reducing the need to power air conditioners, but they can also block sunlight in winter, making it harder to keep houses warm. The net result is often increased annual energy use.

ANNUAL ENERGY EFFECTS AT GOLDEN RESIDENTIAL CASE STUDIES

EXISTING TREES (VERSUS NO TREES)

Energy lost	Money saved	Carbon dioxide emissions avoided
-276 kBtu	$23	196 lbs

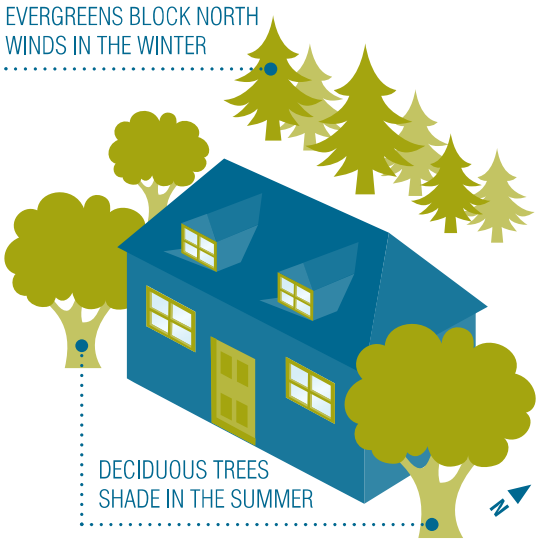
Overall, existing and improved trees created increased energy demand on an annual basis.

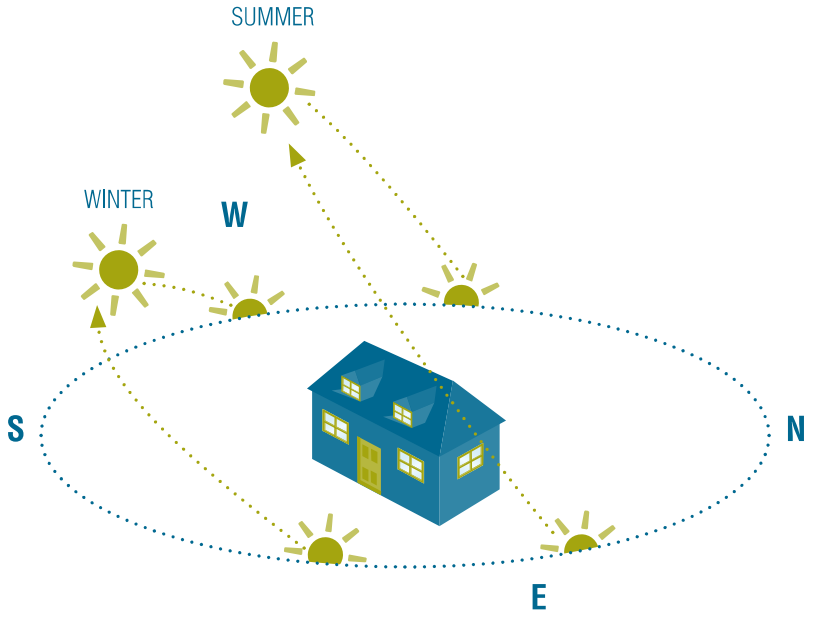
IMPROVED TREES (VERSUS EXISTING TREES)

Net energy impact	Money saved	Carbon dioxide emissions avoided
-742 kBtu	$25	709 lbs

Net positive economic and carbon benefits resulted because energy saved in summer is more expensive and more carbon-intensive.

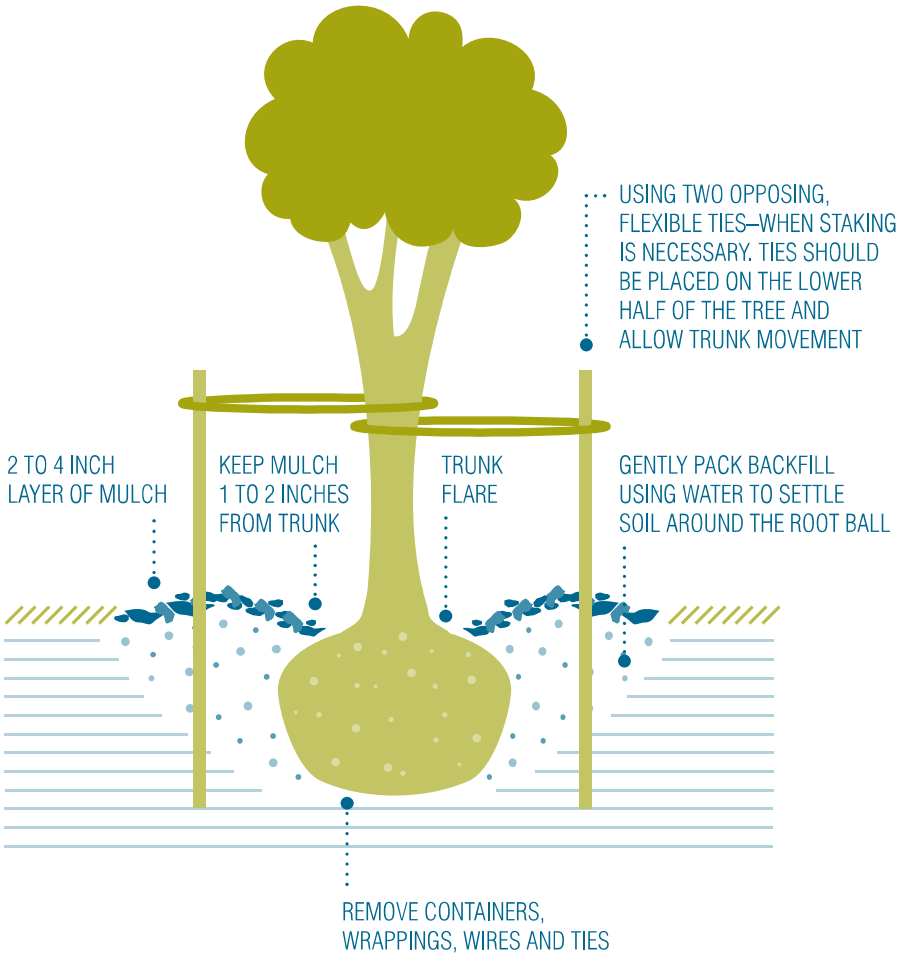
Large, broad-leafed shade trees such as the bur oak, linden and hackberry are most effective shading the east and west windows of your home from the summer sun. Keeping the south-facing windows open to the winter sun reduces your need for heat in the winter.





PLANTING AND MAINTENANCE TIPS

- Plant in early spring or late fall.
- Plant to root bulge.
- Water deep and slow.
- Leave trimming to pros.
- Mulch within drip line.
- Keep mulch off of the trunk.
- Do not fertilize in first year.
- Minimize fossil-fuel use during maintenance.
- Plant trees in energy-conserving locations.



SPECIES SELECTION

WHAT TO CONSIDER:

- Mature size
- Mature shape
- Whether tree has fruit, nuts, thorns
- Drought tolerance, watering regime
- Your environmental priorities

SPECIES THAT CAN IMPROVE AIR QUALITY

WHITE ASH

LITTLELEAF LINDEN

HORSECHESTNUT

HAWTHORN

SPECIES THAT CAN HARM AIR QUALITY

HONEY LOCUST | BUR OAK | BLACK WALNUT | PONDEROSA PINE

SPECIES THAT CAN IMPROVE WATER CONSERVATION

KENTUCKY COFFEETREE

HACKBERRY

BUR OAK

WESTERN CATALPA

SPECIES THAT CAN HINDER WATER CONSERVATION

PLAINS COTTONWOOD | RUSSIAN OLIVE | WEEPING WILLOW | EASTERN REDBUD

Tree photos provided by the Colorado Tree Coalition, www.coloradotrees.org.

SPECIES THAT SEQUESTER CARBON QUICKLY

GREEN ASH

FREEMAN
("AUTUMN BLAZE") MAPLE

HORSECHESTNUT

KENTUCKY
COFFEETREE

SPECIES THAT DO NOT SEQUESTER CARBON QUICKLY

HAWTHORN

LITTLELEAF LINDEN

AMERICAN LINDEN

BRISTLECONE PINE

SPECIES NOT RECOMMENDED

SILVER MAPLE	SIBERIAN ELM	RUSSIAN-OLIVE	WHITE POPLAR
Decays internally to a hazardous degree.	*Leaf and bark beetles, wet wood, aggressive suckering and seeding, can be invasive.*	*Excessive dieback, invasive in waterways.*	*Brittle wood, breaks apart easily.*

TREE OF HEAVEN	QUAKING ASPEN	WILLOW	BOXELDER
Much shedding, brittle wood, aggressive suckering and seeding.	*Many pests, short-lived.*	*Shed many branches, brittle wood.*	*Boxelder beetles, internal decay.*

OVERLAPPING BENEFITS

With so many environmental impacts to consider, choosing a tree can seem like an overwhelming task. When you are ready to make a selection, consider your own environmental priorities and space constraints first. Then look around to see what types of trees are already growing in your area (remember, diversity is key to forest health). Finally, choose a recommended tree that meets your environmental and aesthetic needs.

The table below is an example of one way to compare common tree species based on multiple categories of environmental performance.

COMMON NAME	GOOD FOR AIR	GOOD FOR WATER	GOOD FOR ENERGY	GOOD FOR CARBON
Horsechestnut	x		x	x
White Ash	x		x	
Green Ash	x	x	x	x
White Fur	x			x
Hawthorn Cultivars	x	x		x
Bristlecone Pine	x	x	x	x
Littleleaf Linden	x		x	x
Austrian Pine	x		x	x
Honeylocust	x	x		x
Kentucky Coffeetree	x	x	x	x
Douglas-Fir	x			x
Common Hackberry		x	x	x
Bur Oak		x	x	
Western Catalpa		x	x	x
Oakleaf Mountain Ash	x		x	x

OTHER CONSIDERATIONS

BEFORE YOU PLANT YOUR TREE, THERE ARE A FEW OTHER THINGS TO CONSIDER

Are there any utility lines to avoid such as overhead wires and underground pipes?

CALL BEFORE YOU DIG. Check with your local utility providers to locate underground hazards.

Where are your existing trees and how big are they?

Think about how your new tree will interact with your existing landscape, now and when all your plants are full size.

How much room do you have between your house and your fence or the street or another tree?

Trees need plenty of space to stay healthy and to minimize maintenance cost. Do not plant a tree where it will eventually compete for space with buildings, fences or other objects.

Do you or your neighbor have solar panels?

Tree shading may interfere with the operation of solar water heaters and photovoltaics.

Will planting a tree here damage a sidewalk, driveway or other hard surface?

If correctly watered, most trees should not pose a problem to walking and driving surfaces. Ask a forester or other tree care professional for more recommendations on preventing tree root damage.

Will the tree drop fruit, nuts, leaves, or needles?

All trees require some maintenance. When you collect tree litter consider composting.

How much does the tree cost?

Many communities offer assistance for residents who want to plant trees. Find out about your town's forestry program.

Will it have to be trimmed frequently, or is this tree fairly self-maintaining?

Less maintenance means less energy used.

Trees are a valuable part of the urban environment. In order to optimize the benefits trees can provide it is important to select, plant and maintain trees strategically. Whether your goal is to lower your energy bill, clean up the air, or slow global climate change, trees can be part of your solution!

ADDITIONAL RESOURCES

PLANT-IT 2020

www.plantit2020.org Plant-It 2020 is a nonprofit foundation dedicated to properly planting, maintaining and protecting as many indigenous trees as possible worldwide

THE IES MODEL MUNICIPAL ENVIRONMENTAL TREE GUIDELINES

(with additional recommended tree species)

www.i4es.org/MMETG.pdf IES is a Denver-based nonprofit 501(c)(3) organization dedicated to addressing complex environmental challenges.

TREESCAPES

www.i4es.org/treescapes.htm Online tree selector and benefits calculator tool for homeowners.

CSU EXTENSION "TREE SELECTION: RIGHT PLANT, RIGHT PLACE"

www.ext.colostate.edu/mg/files/gardennotes/632-Treeselection.html

COLORADO TREE COALITION

www.coloradotrees.org The Colorado Tree Coalition is a non profit organization leading Colorado's efforts to preserve, renew, and enhance community forests.

INTERNATIONAL SOCIETY OF ARBORICULTURE – TREE CARE INFORMATION BROCHURES

www.isa-arbor.com This website provides 18 tree care information brochures.

CENTER FOR URBAN FOREST RESEARCH

www.fs.fed.us/psw/programs/cufr Since 1992, this research center has provided reliable scientific evidence that the benefits of urban forests add real value to communities.

URBAN FOREST ECOSYSTEMS INSTITUTE

www.ufei.org The Urban Forest Ecosystems Institute (UFEI) was developed by faculty in the Natural Resources Management Department (College of Agriculture at California Polytechnic State University, San Luis Obispo, California) to address the increasing need for improved management of the urban forests in California.

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