INSTITUTE FOR ENVIRONMENTAL SOLUTIONS

Model Municipal Environmental Tree Guidelines
GOLDEN, COLORADO

SCIENTIFIC SOLUTIONS FOR A BETTER ENVIRONMENT

THE INSTITUTE FOR ENVIRONMENTAL SOLUTIONS IS AN INDEPENDENT NON-PROFIT ORGANIZATION DELIVERING PROACTIVE TECHNICALLY SOUND SOLUTIONS TO COMPLEX ENVIRONMENTAL AND NATURAL RESOURCE PROBLEMS—WITHOUT UNWANTED SIDE EFFECTS.

May, 2008

Model Municipal Environmental Tree Guidelines
GOLDEN, COLORADO

TABLE OF CONTENTS

A. INTRODUCTION 3

B. ENVIRONMENTAL IMPROVEMENT GOALS 3

1. GOAL: IMPROVE AIR QUALITY 4
2. GOAL: WATER CONSERVATION 6
3. GOAL: ENERGY CONSERVATION 8
4. GOAL: CARBON SEQUESTRATION 12

C. BALANCING ENVIRONMENTAL TRADEOFFS 13

D. RECOMMENDED ORNAMENTAL TREES 15

E. TREES NOT RECOMMENDED FOR PLANTING 15

F. PRACTICAL PLANTING CONSIDERATIONS 15

1. HOW TO SELECT YOUR TREE 16
2. HOW TO PLANT YOUR TREE 16
3. HOW TO CARE FOR YOUR TREE 17

G. TREE PROTECTION AND PRESERVATION 18

1. DRAFTING AN ORDINANCE 18

H. CONCLUSIONS 19

REFERENCES 21

April 29, 2008
Desirée Thorp
Research Associate
Institute for Environmental Solutions
Desiree@I4ES.org

Institute for Environmental Solutions
761 Newport Street
Denver, CO 80220-5554
www.I4ES.org

© Copyright 2008 All rights reserved.

Model Municipal Environmental Tree Guidelines
City of Golden, Colorado

A. Introduction

Trees provide a multitude of environmental benefits, such as improved water and air quality, increased habitat for animals and insects, energy conservation and carbon sequestration. However, trees can also have economic or environmental costs; trees need water, a limited resource in Colorado, and trees emit biogenic volatile organic compounds (BVOC), which are precursors to ozone (or smog) formation. Colorado's Front Range communities face many challenges in their landscaping such as an arid, harsh climate and water restrictions in times of drought. Water quality and conservation are important given the region's population growth and industry. Air quality has been a longstanding concern given the Denver-metro area's pollutant-trapping geography and meteorology (along with a recent ozone nonattainment designation by the Environmental Protection Agency). Carbon emissions and sequestration are also important factors in the growing global climate change response. Trees, properly selected, planted and maintained, can benefit the environment in all of the areas mentioned above by adhering to the following guidelines.

This document is designed to go beyond a typical street or landscape design ordinance to provide planners, developers, landscapers, and residents in the Colorado Front Range ideas in using tree planting (tree species selection, placement, and maintenance) to improve urban environmental quality. Most ordinances regarding public and private trees do not consider the potential environmental benefits trees can provide if the right species is selected and planted in the right place. The goal of these guidelines is to provide information on trees' potential environmental impact on different media like air and water, so people can choose which benefits are most important to them and the most can be made of the complex tradeoffs involved in tree selection and maintenance.

Along with existing research, these guidelines, including all of the trees recommended or not recommended in the tables below, incorporate results and observations from the scientific study the Institute for Environmental Solutions (IES) conducted during the summer and fall of 2007 in the City of Golden, Colorado. The study examined the city's existing trees, many of which are not desirable to be planted and may even be classified as invasive species. Currently, Golden has large tree populations of Siberian elm, Russian-olive, quaking aspen, silver maple, plains cottonwood, and blue spruce. Because of their maturity, these trees are providing substantial benefits. However, each of the trees named above has undesirable characteristics; e.g., the plains cottonwood is native but requires a lot of water to thrive. All trees are simply not 'all good' for the environment; although all trees realize some benefits, some trees realize more than others. These guidelines will advise people on which trees could be planted to realize urban environmental improvement with the lowest cost or environmental degradation.

B. Environmental Improvement Goals

This document addresses environmental goals including air quality, water conservation, energy conservation, and carbon sequestration. Each section will contain an explanation of the environmental benefits and costs and lists of both helpful trees and potentially harmful trees.

1. Goal: Improve Air Quality

Trees improve air quality by absorbing carbon dioxide and filtering out particulate air pollution, a process called respiration. Trees can serve as a physical buffer between pollutant emitting sources like highways and parking lots and places where people are working and playing. Trees have the ability to improve air quality efficiently and inexpensively by providing the following eco-services:

- Reducing air temperatures
- Increasing oxygen levels
- Intercepting and trapping particulate matter air pollution
- Absorbing gaseous pollutants
- Binding or absorbing water soluble pollutants on leaf surfaces
- Reducing ozone levels

Trees and soil act as filters by intercepting tiny airborne particles of pollution such as dust, dirt, ash, etc., which have been associated with increasing human respiratory and cardiovascular disease. Virtually all of particulate matter pollution (PM) is the result of combustion, i.e. cars, lawn mowers, construction vehicles, and industrial processes that produce smoke and diesel soot. PM consists of a mixture of liquid or solid coarse (larger) particles and fine particles, from a source or from complex chemical reactions in the air with gases such as nitrous oxides and sulfur oxides. PMs can change from gas to particle form, and can vary by time of year, location, temperature, humidity, and wind (Center for Urban Forest Research 2005).

As particle pollution is transported by wind, tree leaves, and branches intercept them through dry deposition – the particles settle on surfaces of the plant without the aid of precipitation. Particles can then be chemically altered by the plant tissue, metabolized, and absorbed, re-suspended by wind, or deposited to the ground with leaf fall (Scott et al. 1998). This is important because the tree is cleaning the air of pollution. Trees with dense canopies and broad leaves will trap more pollution than trees with narrow, sparse leaves. The trees in table 1 are listed as either able to improve or harm air quality in terms of ozone. The trees in the left columns of table 1 are not as bad for air quality because they do not emit as many BVOC; for trees that can harm air quality and emit higher amounts of BVOC (trees to think twice about planting), see the right columns of table 1.

Table 1. Trees that can improve and harm air quality

TREES THAT CAN IMPROVE AIR QUALITY		TREES THAT CAN HARM AIR QUALITY	
Scientific name	**Common name**	**Scientific name**	**Common name**
Aesculus hippocastanum	Horsechesnut	*Salix alba 'Tristis'*	Weeping Willow
Fraxinus Americana	White Ash	*Picea pungens*	Blue Spruce
Fraxinus pennsylvanica	Green Ash	*Juglans nigra*	Black Walnut
Carpinus betulus	European Hornbeam	*Pinus edulis*	Pinyon Pine
Pyrus calleryana	Callery Pear	*Pinus ponderosa*	Ponderosa Pine
Pyrus communis	Common Pear	*Acer saccharinum*	Silver Maple
Malus species	Crabapple cultivars	*Populus tremuloides*	Aspen
Crataegus species	Hawthorne cultivars	*Quercus macrocarpa*	Bur Oak
Tilia cordata	Littleleaf Linden	*Gelditsia triacanthos*	Honeylocust
Pinus aristata	Bristlecone Pine	*Populus sargentii*	Plains Cottonwood
Sorbus x thuringiaca	Oakleaf Mountain Ash		
Pinus nigra	Austrian Pine		
Pseudotsuga menziesii	Douglas-fir		
Abies concolor	White Fir		
Gleditsia triacanthos	Honeylocust		
Gymnocladus dioicus	Kentucky Coffeetree		
Quercus alba	White Oak		
Sophora japonica	Japanese Pagoda Tree		

Careful! Trees can be Detrimental to Air Quality.

Plants manufacture and emit a variety of substances called phytochemicals, many of which are reactive volatile organic compounds (VOCs), namely isoprene and monoterprene. These compounds evaporate easily into the air and, when mixed with certain toxins, can contribute to air pollution. Tropospheric, or ground-level ozone pollution, is formed in the atmosphere through the combined photochemical reaction of VOCs, Nitrous Oxide (NO_x), and sunlight. Therefore, the highest ozone levels generally occur in bright, balmy, urban areas (where nitrous oxide levels are higher) during the summer, when sunlight is more intense and meteorological conditions are more stagnant (Lyons 1999).

While the Colorado climate may not be ideal for extreme VOC production, as long as NO_x and sunlight are present, and ozone levels are already critical, added trees may have a larger influence than previously thought. Careful tree selection has the potential to improve ozone levels, as trees do take in certain levels of ozone through their biomass. As noted by Dr. David Nowak of the U.S. Forest Service, (n.d.) “In urban areas with 100% tree cover (i.e., contiguous

forest stands) short-term improvements in air quality (one hour) from pollution removal by trees were as high as 15% for ozone."

Proper Placement for Improved Air Quality

Trees planted as barriers – or living fences – to highways and trucking routes will help reduce the pollution that permeates from the thoroughfares. Proper placement depends on site, but trees along roadways and in parking lots (shading pavement and vehicles from the sun) are especially good at pollution uptake (CO, PM10, SO_2, and NO_x). Trees make great barriers/filters to street debris and any kind of carbon emissions as well.

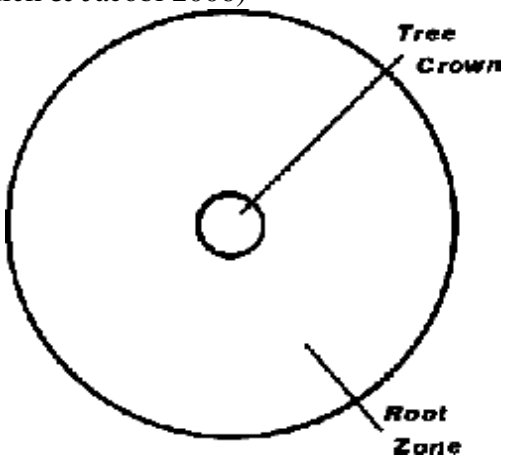
Trees have a dynamic impact on air quality; they can improve air quality or they can harm air quality depending on many other factors such as temperature, wind, weather and anthropogenic (human) emissions (factors which can not be controlled). In general, broad leaf deciduous and pine trees are great for absorbing PM10, carbon, and the other pollutants, but pines and cottonwoods can be detrimental to air quality in the way of ozone forming potential due to VOC emissions. By carefully selecting which tree to plant, you can also improve Golden's air quality (see table 1 above.)

2. Goal: Water Conservation

The Front Range is naturally a "semi-arid, shortgrass prairie that would have few trees without irrigation" and where periods of drought are common. The trees planted in communities along the Front Range are often not native and are accustomed to environments that receive over 30 inches of rainfall a year (Fort Collins 2006). Denver's average rainfall is 15.4 inches a year and Fort Collins is similar, receiving 15 inches per year. According to the City of Fort Collins, even established trees need between 22 inches and 25 inches of water each year to grow at a moderate rate; therefore, most trees in the Front Range require some irrigation.

Proper watering is essential. Generally, a tree's roots extend outward to several times the canopy's size (figure 1). This entire root area should be watered. During water restrictions, trees may be given higher priority than lawns for the simple reason that it is easier and less costly to replace a lawn than it is to replace a 20 year old tree (Fort Collins 2006).

Figure 1. Tree root zone (Sillick & Jacobi 2006)



Supplemental watering is also important in Colorado's dry fall and winter; "Woody plants going into winter with dry soil conditions lose approximately 20 degrees in hardiness (Whiting et al. 2007b)." Trees should be watered after the leaves drop but before the ground freezes.

Another important consideration for tree watering is root depth. Trees should be watered differently than shallow-rooted plants; water must be applied for longer duration in order to provide moisture deeper in the soil. Trees grown under irrigation regimes featuring multiple, shorter applications may grow shallow root systems, ultimately decreasing hardiness (Klett et al. 2007).

The question, "How much should I water this tree?" is still unanswerable in specific terms. General recommendations can be made based on anecdotal evidence and initial scientific findings. The issue is complicated by the fact that various species respond differently to moisture levels, and a tree responds to varying levels of moisture in the environment in different ways at different points in its life. The moisture available also depends on other factors such as the type of soil, how the tree was planted, its location relative to other vegetation and structures, and competition for the water from other plants. Some trees, which are referred to as 'drought tolerant,' may be able to survive brief periods of very low moisture availability but struggle in a generally arid environment while others may thrive in a dry region but be intolerant of brief periods of extreme drought; some may struggle to become established as young trees but thrive as adults (Whiting et al. 2007b). Trees considered to be low-water, or xeric (Feucht 1999), are listed in the left columns of table 2 while trees which may require more supplemental water are listed in the right columns of table 2.

Table 2. Trees that may improve or hinder water conservation

TREES THAT MAY IMPROVE WATER CONSERVATION		**TREES THAT MAY HINDER WATER CONSERVATION[1]**	
Scientific name	**Common name**	**Scientific name**	**Common name**
Crataegus species	Hawthorne cultivars	*Populus sargentii*	Plains Cottonwood
Gymnocladus dioicus	Kentucky Coffeetree	*Salix alba 'Tristis'*	Weeping Willow
Celtis occidentalis	Common Hackberry	*Elaeagnus angustifolia*	Russian-olive
Quercus macrocarpa	Bur Oak	*Acer ginnala*	Amur Maple
Quercus gambelii	Gambel Oak	*Amelanchier species*	Serviceberry cultivars
Acer grandidentatum	Bigtooth Maple	*Cercis canadensis*	Eastern Redbud
Gleditsia triancanthos inermis	Thornless Honeylocust	*Prunus species*	Cherries/Plums/Chokecherries

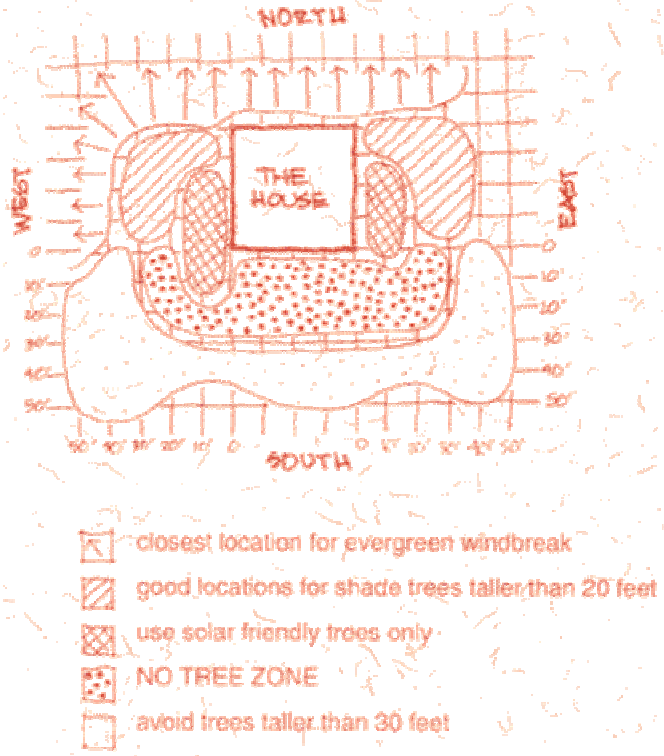
[1] Trees listed here are either 'known' for being high-water users or are rated as 'requires more water' by the Garden Centers of Colorado (City of Aurora 2007).

TREES THAT MAY IMPROVE WATER CONSERVATION		TREES THAT MAY HINDER WATER CONSERVATION[1]	
Scientific name	**Common name**	**Scientific name**	**Common name**
Catalpa speciosa	Western Catalpa	*Malus species*	Apple and Crabapple
Fraxinus pennsylvanica	Green Ash		
Robinia neomexicana	New Mexican Locust		
Koelreuteria paniculata	Goldenrain Tree		
Pinus ponderosa	Ponderosa Pine		
Pinus aristata	Bristlecone Pine		
Juniperus scopulorum	Rocky Mountain Juniper		
Juniperus monosperma	One-seed Juniper		
Pinus edulis	Pinyon Pine		

3. Goal: Energy Conservation

Properly selected, sited, and maintained trees can provide substantial energy savings in the winter and summer (see figure 2 for planting different types of trees in different locations around the home for energy conservation). To increase energy conservation, trees should be placed to the east and west sides of a home, shading windows (the sun is high in the sky in the summer, making planting a tree on the south side for shading less effective, see figure 3). Trees shading windows and walls in the summer help keep the temperature both inside and outside of the home cooler. Planting large, deciduous, shade trees on the west side of a home is the best way to reduce a home's need for air conditioning in the summer. See table 3 for recommended shade trees. Shade trees on the east serve the same purpose, but provide less cooling in the morning than the shade trees on the west do in the late afternoon. Planting evergreen trees to the north and northwest sides of a home will act as a windbreak (figure 4), reducing the rate of outside air's infiltration into a heated or air conditioned home. Evergreens recommended for Golden are listed in table 4. An important fact to note is that some of the trees recommended for energy conservation may not be good for air quality or water conservation. There is no perfect tree that is good for all environmental benefits; they all have tradeoffs in term of the benefits and costs they will realize.

Figure 2. Tree placement for energy conservation (Minnesota Tree Care Advisors 2003)



Shading dark, absorptive surfaces, such as black asphalt, will reduce overall ambient air temperatures. Through the process of transpiration, trees draw water from the soil into their roots and release water through the leaf stomata, which then mixes with the heat from the air to form water vapor, cooling and adding humidity to the air. This reduction in ambient air temperature leads to decreased use of air conditioning in cars and in buildings which lowers CO_2 emissions significantly.

Table 3. Trees with deep and less deep shade[2]

TREES WITH DEEP SHADE		**TREES WITH LESS DEEP SHADE**	
Scientific name	**Common name**	**Scientific name**	**Common name**
Picea pungens	**Blue Spruce**	***Populus tremuloides***	**Quaking Aspen**
Pinus nigra	**Austrian Pine**	***Gleditsia triacanthos***	**Honeylocust cultivars**
Fraxinus americana	**White Ash**	***Betula Nigra***	**River Birch**
Acer saccharinum	**Silver Maple**		
Fraxinus pennsylvanica	**Green Ash**		

[2] The trees in bold and characterized with 'deep' or 'less deep' shade had the transmissivity of their canopies measured. The trees with less deep shade allow more sunlight to pass through, albeit not as much as if the tree had no leaves, i.e., the honeylocust and its cultivars are characterized as having open foliage (Haserodt and Sydnor 1983).

TREES WITH DEEP SHADE		**TREES WITH LESS DEEP SHADE**	
Scientific name	**Common name**	**Scientific name**	**Common name**
Malus species	**Crabapple**		
Prunus species	**Cherry**		
Quercus macrocarpa	**Bur Oak**		
Pinus aristata	**Bristlecone Pine**		
Juniperus Scopulorum	**Rocky Mountain Juniper**		
Betula nigra	**River Birch**		
Populus tremula 'Erecta'	**Upright European Aspen**		
Sorbus x thuringiaca	**Mountain Ash**		
Acer platanoides	**Norway Maple**		
Ulmus Americana	**American Elm**		
Fraxinus Americana 'Autumn' 'purple'	Autumn Purple Ash		
Catalpa speciosa	Western Catalpa		
Gymnocladus dioicus	Kentucky Coffeetree		
Celtis occidentalis	Common Hackberry		
Aesculus hippocastanum	Horsechestnut		
Tilia cordata 'Chancellor'	Littleleaf Linden		
Tilia americana 'Legend' or 'Redmond'	American Linden		
Acer x freemanii 'Autumn Blaze'	Autumn Blaze Maple		
Quercus alba	White Oak Cultivars		
Quercus rubra	Northern Red Oak		

Careful! Trees can be Detrimental to Energy Conservation.
Colorado is a cold weather climate; which means that homes require more energy for heating in the winter than for cooling in the summer. In this climate, it is important to leave south facing windows and walls open to the sun's warming rays in wintertime. Some guides recommend planting deciduous trees to the east, south, and west of a home to shade it from the sun in the summer, but in Colorado it is wise to keep shade trees limited to the east and west sides of a home. The summer sun is high in the sky and a shade tree to the south does little to shade the home (see figure 3). That same tree, however, would shade the house from the winter sun, which is low in the sky to the south, requiring the inhabitants to run the furnace longer to maintain a comfortable temperature.

Figure 3. Sun's position in the sky in winter versus summer (Whiting et al. 2007a)

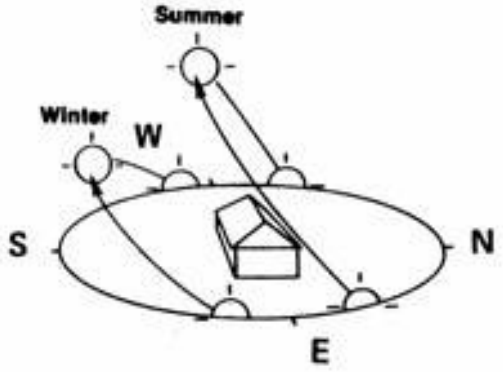


Table 4. Recommended Evergreens for Golden[3]

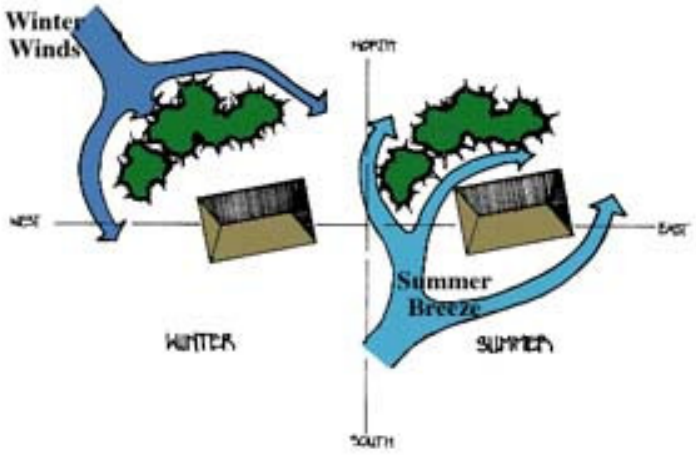
Scientific Name	**Common Name**
Pseudotsuga menziesii	Douglas-fir
Abies concolor	White Fir
Juniperus scopulorum	Rocky Mountain Upright Juniper
Pinus nigra	Austrian Pine
Pinus aristata	Bristlecone Pine
Pinus edulis	Pinyon Pine
Pinus ponderosa	Ponderosa Pine

Proper Placement for Energy Conservation

Tall, broad-leafed, deciduous trees are the best trees to shade a home. Large trees need space to grow. Before you plant a large deciduous tree by your home, find out how tall and wide the tree will get. Leave ample space for it to grow. An unhealthy tree, without enough space to grow, may cause property damage and will not realize its full potential in terms of environmental benefits. Place large shade trees far enough from your house to give them adequate room to grow and place them to the east or west sides. Avoid planting large shade trees or any evergreen trees to the south; they will block the winter sun from heating your home.

[3] While these evergreens are recommended for Golden, some of them may not perform well at lower elevations along the Front Range.

Figure 4. An illustration of where to plant trees – to the north and west of a building – to act as a windbreak (Welch n.d.)



4. Goal: Carbon Sequestration

Trees remove carbon dioxide from the air both directly and indirectly. As trees "breathe", they directly absorb carbon dioxide and release oxygen through their leaves. Through the process of photosynthesis, trees remove the carbon from the CO_2 (CO_2 = 1 carbon atom and 2 oxygen atoms) and stores it as cellulose in their biomass (i.e., trunk, leaves, stems, roots, branches) while releasing the oxygen back into the air. The amount of carbon absorbed annually varies by as much as 35 to 800 lbs., depending on tree growth rate, age, and size (see table 5 for recommended trees to plant which sequester carbon). In general, a mature tree may absorb 1,000 times more than small, young trees (EPA 2005). Urban forests play an important role in atmospheric carbon levels and should not be overlooked as a valuable tool in reducing these levels. In fact, the U.S. Forest Service estimates that carbon storage in urban forests' above-ground biomass is between 400 and 900 million metric tons nationally (City of Boulder 2002).

A large portion of sequestered carbon is stored in the trees above-ground biomass system, however, the below ground root system actually offers great potential for mitigating atmospheric carbon levels. The combination of porous soil and the extensive root system below a mature tree stores more carbon than tree trunk, stems, leaves, and branches combined. Most of the carbon stored in soil comes from decaying organic matter such as leaves or other dead plant biomass.

Though in general trees provide for an overall net decrease in atmospheric carbon, they also 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 releasing machinery such as chippers, chain saws, vehicle emissions, etc. Golden's existing trees are storing 16,400 metric tons of carbon and sequester another 637 metric tons each additional year. Seasonal fluctuations in energy costs, fuel mix, and the resulting carbon emitted from the production of electricity can result in economic savings even despite an increase in fuel use in the winter. The energy analysis of The Tree Project (see the Phase 2 Report at http://www.instituteforenvironmentalsolutions.org/treeproject.html) found that on some properties, trees caused an increased need for energy in the winter but the savings

produced by the same trees in the summer amounts to a net reduction in carbon emissions of 195 tons per year.

Table 5. Recommended trees to plant to sequester carbon

Scientific Name	**Common Name**
Fraxinus americana 'purple'	Autumn purple ash
Fraxinus pennsylvanica	Green ash
Catalpa speciosa	Western catalpa
Gymnocladus dioicus	Kentucky coffeetree
Celtis occidentalis	Hackberry
Gelditsia triacanthos	Honeylocust
Aesculus hippocastanum	Horsechestnut
Tilia cordata	Littleleaf linden
Tilia americana 'Legend' or 'Redmond'	American linden
Acer x freemanii 'Autumn blaze'	Autumn blaze maple
Quercus alba	White oak
Quercus rubra	Northern red oak
Sorbus x thuringiaca	Oak-leaf mountain ash
Alnus tenuifolia	Thin-leaf alder
Aesculus glabra	Ohio buckeye
Malus spp.	Crabapple
Crataegus species	Hawthorne
Acer campestre	Hedge maple
Pyrus spp.	Pear
Sophora japonica	Pagoda
Quercus robur 'Fastigiata'	English oak
Pseudotsuga menziesii	Douglas fir
Abies concolor	White fir
Juniperus scopulorum	Rocky mtn. upright juniper
Pinus Nigra	Austrian pine
Pinus aristata	Bristlecone pine
Pinus ponderosa	Ponderosa pine
Pinus syslvestris	Scotch pine
Pinus strobiformis	Southwest white pine
Juniperus virginiana	Eastern redcedar
Picea pungens	Colorado spruce

C. Balancing Environmental Tradeoffs

Some benefits trees provide are more valuable than others, either personally or monetarily. Trees provide the most savings dollar-wise in stormwater reduction services, but most people's environmental and monetary priorities are not stormwater, but rather energy or water conservation. The best way to select a tree for environmental improvement is to determine your priorities first and then select an appropriate tree. It is important to consider all of the potential

environmental costs and benefits when selecting the right species and choosing an appropriate location for your tree. Table 6 compiles trees whose environmental costs and benefits overlap.

Table 6. Overlapping environmental benefits of trees listed above[4]

Common Name	Good for Air	Good for Water	Good for Energy	Good for Carbon
Horsechesnut	X		X	X
White Ash	X		X	
Green Ash	X	X	X	X
White Fir	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
Autumn purple ash			X	X
American linden			X	X
Autumn blaze maple			X	X
White oak	X		X	X
Northern red oak			X	X
Oakleaf mountain ash	X		X	X
Crabapple	X		X	X
Pear	X			X
Pagoda	X			X
Rocky Mountain juniper		X	X	X
Ponderosa pine		X		X
Blue spruce			X	X

[4] This table is not exhaustive. The trees listed here were either studied in Golden or recommended by other sources mentioned above.

D. Recommended Ornamental Trees

Ornamental trees are smaller in stature but still provide all of the same environmental benefits of larger trees on a smaller scale; they sequester carbon and trap particulate matter. Ornamental trees can shade air conditioners in the summer, reducing the amount of energy the AC unit needs to cool the inside as well as sidewalks and driveways to keep the air temperatures down. For a list of recommended ornamental trees see table 7.

Table 7. Recommended ornamental trees

Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Syringa reticulata	Tree Lilac	*Sorbus x thuringiaca*	Oak-Leaf Mountain Ash
Alnus tenuifolia	Thin-Leaf Alder	*Aesculus glabra*	Ohio Buckeye
Malus spp.	Crabapple cultivars	*Prunus montmorency*	Montmorency Cherry
Corylus colurna	Turkish Filbert	*Crataegus species*	Hawthorne cultivars
Carpinus betulus	European Hornbeam	*Prunus virginiana 'Schubertii'*	Canada Red Chokecherry
Prunus padus commutata	Mayday Tree	*Cercocarpus montanus*	Mountain Mahogany
Acer campestre	Hedge Maple	*Acer ginnala*	Ginnala Maple
Acer Tataricum	Tartarian Maple	*Pyrus species*	Pear cultivars
	Gambel Oak	*Sophora japonica*	Pagoda Tree
Xanthoceras sorbifolium	Yellowhorn	*Quercus robur 'Fastigiata'*	Columnar English Oak

E. Trees Not Recommended for Planting

The following is a list of trees which are not recommended for planting with the reasons why they are undesirable / unsuitable and should not be planted:

- Silver maple — Decays internally to a hazardous degree.
- Siberian elm — Leaf and bark beetles, wet wood, aggressive suckering/seeding, can be invasive.
- Russian-olive — Excessive dieback, invasive into waterways.
- White poplar — Brittle wood, breaks apart easily.
- Tree of heaven — Much shedding, brittle wood, aggressive suckering/seeding.
- Quaking aspen — Many pests, short-lived.
- Willow — Shed many branches, brittle wood.
- Boxelder — Boxelder beetles, internal decay.

F. Practical Planting Considerations

Every decision to make when planting a tree will affect the environmental costs or benefits it produces. Trees will provide you with ample environmental benefits if the following maintenance practices are taken into consideration.

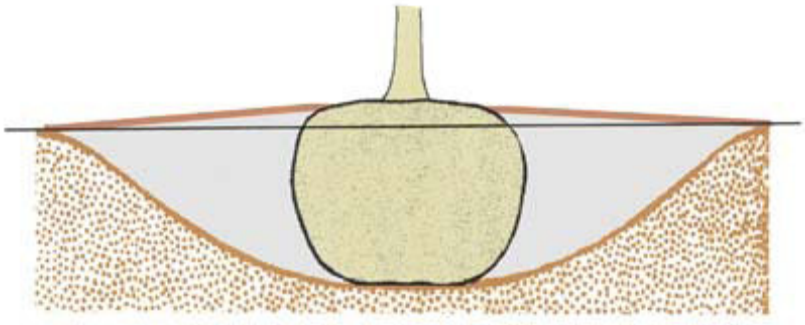
1. How to Select Your Tree

Planting the right tree in the right place is important along the Front Range of Colorado. Trees planted in Colorado should also be grown in this region; trees grown locally are hardy enough to withstand the extreme temperatures found along the Front Range. Also, some trees require extra water, and some can even make our city's air pollution worse! To select the right tree, visit your local greenhouse or nursery, or find good options online at the Colorado State University website: http://csfs.colostate.edu/allabouttrees.htm. Always consider the tree's mature height and width; a tree that does not have enough room to grow will need trimming more often and may damage sidewalks when roots expand upward or other property with falling branches.

2. How to Plant Your Tree

Dig a saucer-shaped hole for the tree that is just deep enough to keep the root collar – the bulge where the trunk meets the roots – above ground. It is *very* important to not bury the root collar (see figure 5 for an example. The hole should be three times wider than the root ball. Place the tree in the center of the hole vertically and refill with the soil you removed. Push the soil in around the roots lightly and water the soil to eliminate air pockets, but *do not* pack the soil. Spread mulch – a protective ground cover often made of shredded wood– over the area (four inches away from the trunk) at a depth of two to three inches. Do not fertilize your tree for at least a year.

Figure 5. Saucer-shaped hole with root collar above ground (Whiting et al. 2007)



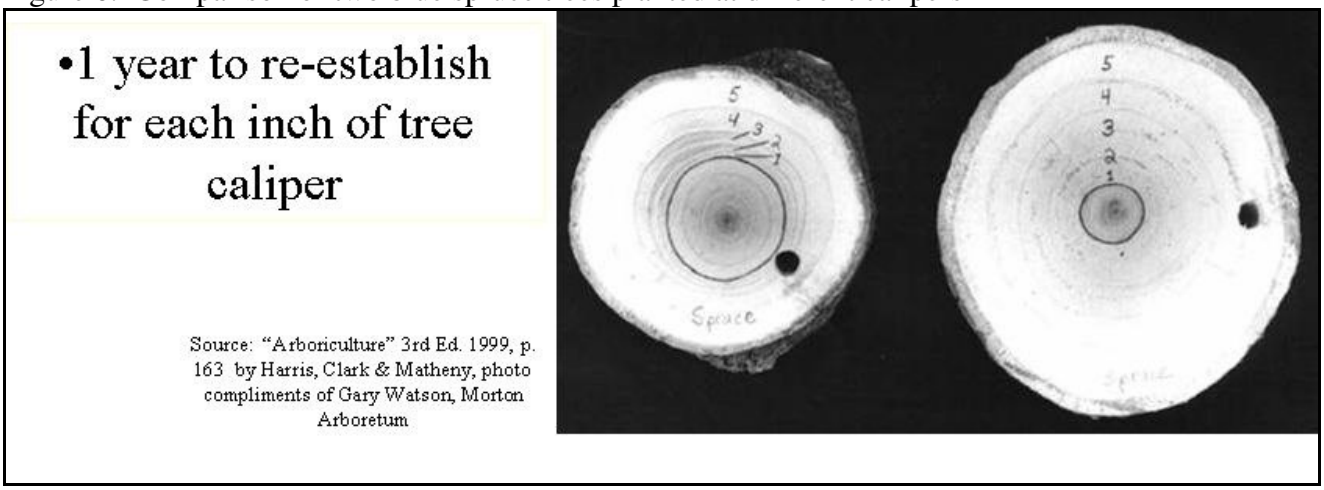
Successful tree planting depends on:

1) Functional design
2) Plant selection
3) Pre-planting handling
4) Planting techniques
5) Post-planting care

Trees with restricted rooting space will grow slower, be smaller and have a shorter life span. Roots may grow under sidewalks and driveways, but typically do not grow under streets because of soil compaction (Whiting et al. 2005). If you give your tree adequate room to grow it will provide you with ample benefits.

Planting smaller caliper trees will decrease the time the tree needs to re-establish itself and increase its growth rate once it is re-established. Consider figure 6 below which illustrates on the left, a larger-caliper tree and on the right, a smaller-caliper tree which were planted at the same time. The black rings indicate the size of the tree when it was planted; the smaller-caliper tree quickly outgrew the larger one.

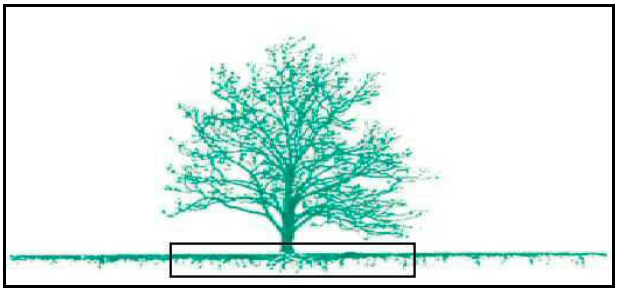
Figure 6. Comparison of two blue spruce trees planted at different calipers



3. How to Care for Your Tree

Regular tree maintenance is important to keep the tree healthy so it can provide the most environmental benefits. Water a tree deeply and slowly within the drip line – the circle formed by the tips of the branches farthest from the trunk. Tree roots can extend out 2 to 3 times the width of the drip line (figure 7) of the tree so be careful not to damage the root system with digging or aerators. Keep grass out of the drip line as well to minimize damage to the trunk from a lawnmower and to increase the water available to the tree. Colorado has a dry climate and most trees need supplemental water.

Figure 7. A tree's drip line (Denver Water 2006)



The Colorado Tree Alliance recommends that trees receive 10 gallons of water for each inch of diameter, so if your tree is two inches in diameter it would need 20 gallons per watering. Trees should be watered once or twice a month during dry periods, depending on their size and establishment status. They also recommend that "During prolonged dry periods in the fall and winter (October - March), water one to two times per month. Water only when the temperature is above 40 degrees and no snow cover exists."

G. Tree Protection and Preservation

One of the most powerful means to ensure that environmental benefits will be maintained and increases in canopy cover will occur will be to protect the existing urban forest from removal during development, or die off. Tree planting to cover tree losses is a viable method to increase canopy cover and decrease the impact of the loss of existing trees. These tree-planting programs could be used to offset losses due to the inevitable development of some of the existing tree-covered land or to replace trees that are lost through natural causes. Steps should also be taken to account for a standard mortality rates. For example, a 1:1 tree replacement ratio, would mean an actual reduction in canopy because it does not factor in the predictable death of the replacement trees themselves**,** or the smaller canopy size caused by young trees (Luley et al. 2002).

Golden's city planning department and city council will be important in this regard as they can enact and enforce local ordinances that protect existing trees and can require replacement of any trees that are removed. Many of these tree preservation guidelines or requirements are in place, but due to lack of compliance or lack of knowledge of the value of the trees in providing environmental and economic benefits, or a lack of staff and proper enforcement measures, these guidelines are often not adhered to.

According to the Minnesota Shade Tree Advisory Committee (MNSTAC) (1995), several steps are essential in ensuring that a preservation ordinance is effective.
First, each community must determine its own needs and goals, and design its ordinance to best achieve these objectives.

The goals of tree preservation ordinances can include:

- Reducing tree loss during development.
- Reducing damage to standing trees during construction.
- Providing for replacement of trees removed during construction
- Providing for planting trees where none occurred previously.
- Providing for the maintenance of preserved trees after construction is completed.

The scope of the ordinance may cover only projects undertaken by the city on public land or it could also include work by utility companies, private residential, commercial or industrial projects. There may be a minimum size for a project to be regulated, measured in land area or in project cost. The ordinance may regulate only tree preservation or may also include replacement and new planting. It may or may not include provisions for education or enforcement. Determining the goals and scope will be an important part of developing the ordinance.

1. Drafting an Ordinance

The process by which the ordinance is developed is as important as the actual language. An ordinance should create a mechanism for the exchange of information. Therefore, the relationships formed during the ordinance development process are crucial to its potential success.

An ordinance marks the creation of a new "organization", composed of people brought together from different professions, positions and interests for the purpose of tree protection. This creation of a working organization takes time for meetings, discussions, and phone conversations. The process must build trust amongst the various parties.

The challenge of an ordinance is not getting it passed, but getting people to follow its provisions. The best ordinances come about when:

1. The ordinance provides for effective communication.
2. Everyone affected has a role in developing the ordinance, starting with the basic objectives.
3. The objectives are simple and easy to communicate.

Most ordinances contain provisions for enforcement and penalties in the event violations occur. Many communities withhold occupancy permits until standards have been met and also require developers to submit performance bonds to ensure that the necessary trees are saved or planted. If protected trees are removed unlawfully, some communities require that a mitigation fee be paid into a special fund, so that the community can replant trees there or elsewhere in the community. Some ordinances also hold developers accountable for tree survival in the initial years following construction, since it may take three to five years for a tree that was injured during construction to decline and die. These communities typically require the developer to either replace the dead trees or pay a special fee. However, according to the National Association of Home Builders (1995), some feel that, “Such provisions are difficult since the long-term care and survival of the trees also depends on the homeowner taking responsibility for them.” This is an example of why key affected parties, or stakeholders, should be involved in the process of creating ordinances, so that they understand not only the aesthetic value of trees, but also the economic and environmental values they bring to communities.

H. Conclusions

Healthy mature landscapes provide notable benefits. These include: a reduction in household energy consumption, sequestration of carbon dioxide, improvements in air quality, reduction in stormwater runoff, and an increase in property values due to the importance that people place on aesthetically and psychologically inspiring surroundings. These benefits are tangible, but the landscapes that provide them may have significant irrigation requirements.

Trees have proven environmental and economic benefits. However, planting trees in Colorado requires special consideration of other factors to ensure the health of the trees, including a proper watering regimen and adequate space. Limited water resources are already stressed in Colorado and demands on supply will only increase as a result of growing urban communities. Conservation measures taken in agriculture, industry, and in and around the home will ease the demand on the limited supply. Trees will continue to provide many benefits as long as the trees planted are appropriate for Colorado’s semi-arid climate and are properly maintained.

Limitations

These guidelines were intended only to include the environmental considerations when planting a tree; there are many others a person should consider as well. If the tree being planted is a street tree consult your city’s street tree ordinance. Often trees which produce thorns or fruit are

prohibited as street trees. Some species will perform better near roadways than others. Some trees can not take too much watering so be careful planting in heavily irrigated areas. Space is also an important consideration when planting a tree. Take care to not plant large trees under utility lines which will then have to be pruned aggressively. Locate the tree so that it will have enough room to grow to its mature height and width for optimal benefits. Always call your local utility providers before you start digging!

References

Center for Urban Forest Research (CUFR) 2005, January. Air Pollution Control-The Tree Factor. Retrieved from: http://www.fs.fed.us/psw/programs/cufr/presentations.php

City of Aurora, 2007. 2007 Xeriscape Plant List. Retrieved from http://www.auroragov.org/stellent/groups/public/documents/article-publication/031243.pdf

City of Boulder, Water Conservation Office. 2002. Calculating the Value of Boulder's Urban Forest. Retrieved from: bcn.boulder.co.us/basin/boulder/urbanforest/onthispage.pdf

City of Fort Collins. 2006. *Caring for Trees during Drought.* Retrieved May 1, 2006 from http://fcgov.com/horticulture/tree-care.php

Denver Water. 2006. *Frequently Asked Questions.* Retrieved May 21, 2006 from http://www.denverwater.org/

Feucht, J. R. 1999. Xeriscaping: Trees and Shrubs. Retrieved from http://www.ext.colostate.edu/pubs/Garden/07229.html

Harris, Clark, & Mathney. 1999. Arboriculture 3rd edition. Pg. 163

Haserodt, H. & Sydnor, T. D. 1983. Growth habitats of five cultivars of Gledistia triacanthos. Ohio Agriculture Research and Development Center. No. 100-82. Wooster, OH.

Klett, James E., Susan Rose, Curtis E. Swift and Carl Wilson. 2007. Woody Plant Management During Drought and with Limited Water Availability in Colorado. Colorado State University Extension. http://www.ext.colostate.edu/drought/woody_plant.html (accessed March 14, 2008).

Luley, C.J., Bond, J. 2002. A report to the North East Foresters Association: a plan to integrate management of urban trees into air quality planning. Retrieved from: http://www.fs.fed.us/ne/syracuse/Pubs/Downloads/Final_report_March2002_Davey.pdf

Lyons, C.E. 31 May, 1999. Biogenic Emissions of Air Pollution: Impact of Tree Planting on Urban Air Quality.

Minnesota Shade Tree Advisory Committee (MNSTAC) 1995. A guide to developing a community tree preservation ordinance. Retrieved from: http://www.mnstac.org/RFC/preservationordguide.htm

Minnesota Tree Care Advisors. 2003. Retrieved April 22, 2008 from http://www.mntca.org/Reference_manual/plant_and_site_selection-energy.htm

Nowak, D. n.d. The Effects of Urban Trees on Air Quality. USDA Forest Service, Syracuse, NY. Retrieved from: http://www.fs.fed.us/ne/syracuse/gif/trees.pdf

Sillick, J. M. & Jacobi, W. R. 2006. Healthy roots and healthy trees. Retrieved from http://www.ext.colostate.edu/PUBS/Garden/02926.html. April 7, 2008.

Scott, K.L., McPherson, E.G., Simpson, J.R. 1998, July. Air Pollutant Uptake by Sacramento's Urban Forest. Journal of Arboriculture. 24(4).

U.S. EPA. 2005. Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture Retrieved from: http://www.epa.gov/sequestration/pdf/greenhousegas2005.pdf

Welch, W. C. n.d. Landscaping for Energy Conservation. Retrieved April 22, 2008 from http://aggie-horticulture.tamu.edu/extension/homelandscape/energy/energy.html

Whiting, David, Robert Cox, and Carol O'Meara. 2007a. GardenNotes #631: Tree Placement: Right Plant, Right Place. Colorado State University Extension. Retrieved April 22, 2008 from http://www.ext.colostate.edu/mg/files/gardennotes/631-Treeplacement.html

Whiting, David, Robert Cox, and Carol O'Meara. 2007b. GardenNotes #632: Tree Selection: Right Plant, Right Place. Colorado State University Extension. http://www.ext.colostate.edu/mg/files/gardennotes/632-Treeselection.html (accessed February 22, 2008).

Whiting, D., Cox, R., Jones, J. & Stoven, A. 2007. The Science of Planting Trees. Retrieved April 22, 2008 from http://cmg.colostate.edu/gardennotes/633.pdf

Whiting, D, Bousselot, J, Cox, R., & O'Meara, C. (2005). *The Science of Planting Trees*. Retrieved June 26, 2006 from http://www.ext.colostate.edu/Pubs/garden/07833.html

April 29, 2008
Desirée Thorp
Research Associate
Institute for Environmental Solutions
Desiree@I4ES.org

Institute for Environmental Solutions
761 Newport Street
Denver, CO 80220-5554
www.I4ES.org
© 2008 All rights reserved.