EXECUTIVE SUMMARY

Putting a Value On Our Urban Forest

Imagine the City of Boulder without trees…it's difficult to do. Trees are an integral part of the urban ecosystem, yet often taken for granted. Most of us recognize the aesthetic value of trees in urban areas and can appreciate the shade they provide during hot summer months, but are only vaguely aware of the myriad environmental benefits that they offer.

As Boulder has grown and developed, so too has the "urban forest". More than 330,000 trees have been planted here over the last century and a half and now cover 23% of urban areas. The semi-arid environment (historical average rainfall in this area is only 18 inches) is not conducive to the green infrastructure of an urban forest; certainly this forest would not have flourished without human care and the development of a complex irrigation system. Large trees native to the Plains include the cottonwood, willow, hackberry and little else, and require a generous supply of water. Prior to settlement these trees could only survive in close proximity to streams and creeks, otherwise known as riparian areas. Presently, we have over 100 different species existing throughout the City, not only lining the banks of creeks and ditches, but also along the streets of residential, commercial, and industrial areas, as well as in public parks.

The History of Boulder's Urban Forest

Many trees that exist in Boulder today were planted over 100 years ago thanks to the foresight of earlier settlers. The current residents of the City are still receiving the aesthetic and environmental benefits of the early-established framework of Boulder's urban forest. Their reasons for planting trees most likely were different than today, but may have included a desire to:

- Simulate the hardwood forests of the Eastern U.S. where many of the settlers originated
- Create more civilized neighborhoods and to instill a "sense of home"
- Provide shade in hot summer months
- Provide a variety of fall color

Landscape Architect Frederick Law Olmsted, Jr., in a report to the City Improvement Association in 1910, wrote "Boulder is properly proud among Colorado towns on account of it's numerous and large street trees. They are an example of the immense effect upon a town's appearance that may rapidly result from a popular custom once set agoing. The result is surely pleasing." Prior to that report many trees had been planted within the City, but haphazardly with out a long-range, large-scale plan. Once the need for formal management was recognized, the conscious planning of Boulder's urban forest began. The report also contained recommendations for tree planting, species selection, pruning, irrigation, and planting design for different street types, and this framework for a managed urban forest is still utilized today by the City of Boulder's Forestry Department.

View of Boulder as seen from the Yount Flour Mill at the mouth of Boulder Canyon, with University of Colorado buildings in the distance. Circa 1870. Photo reproduced with permission from the Denver Public Library's Western History Collection.

Same location, October, 2000. Trees have filled in the city's landscape so that buildings are barely visible.

It is now recognized that tree plantings have provided the community with measurable environmental enhancements throughout the years. These include, but are not limited to:

- Air pollution removal
- Stormwater runoff prevention and water quality improvement, carbon storage and sequestration
- Energy savings provided by shade and evapotranspiration

Quantifying the Environmental Benefits

In the summer of 1999 the City of Boulder began a study that took a closer look at the environmental benefits of the urban forest. The analysis combined the use of aerial photography, Geographic Information Systems (GIS), and computer modeling to quantify the benefits of trees at 34 urban sites.

Environmental Benefits: Site 3 Statistics

Size: 1.5 acres
Canopy Cover: 60%
Number of Homes: 5
Number of Trees: 110

Carbon

Carbon Storage: 29 tons
Carbon Sequestration: 0.7 tons/year

Air Pollution

Air Pollution Removal: $151/year
Air Pollution Removal: 52 lbs/year

Energy Benefits

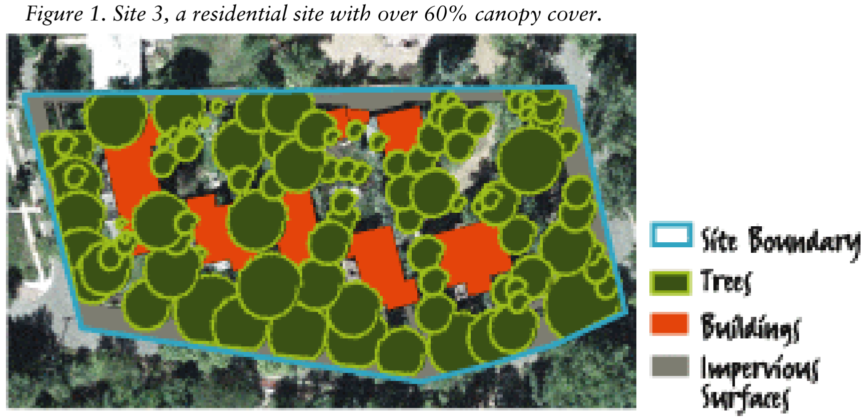
Energy saved by site: $390/6400 kWh/year
Avoided carbon by site: 3660 tons/year

Stormwater:

Avoided Runoff: 2813 cubic feet
Runoff Reduction: 55%
Time of Concentration Increase: 42%
Peak Flow Reduction: 62%

The urban forest was mapped in 5 different land use categories (Residential, Commercial, Industrial, Public/Recreational, and Riparian) to determine of the percentage of each study site covered by tree canopy, buildings, impervious surfaces, and grass. At each site, a tree's species ID, trunk diameter, health, and crown size were cataloged. The data were then entered into CITYgreen, a software package created by American Forests that performs the environmental modeling calculations within the framework of GIS software. Refer to graphic below for an example of the trees mapped at a residential site and the calculation of environmental benefits.

Figure 1. Site 3, a residential site with over 60% canopy cover.



How the Benefits of Trees are Modeled

This study estimated the average canopy cover within the City of Boulder to be 23%. The breakdown for each land use is as follows:

Land Use	Canopy Cover
Residential	31%
Commercial	7%
Industrial	7%
Public	6%
Riparian	40%
Average	**23%**

1. Stormwater Runoff Prevention

Trees benefit water in urban areas in two ways: both by increasing water quality, and by decreasing stormwater runoff. Between storms pollution emitted from vehicles is deposited on roadways and impervious surfaces; rainfall washes these pollutant off and this runoff is delivered to nearby waterways. Not only is the water contaminated, but efficient removal of stormwater from the roadways creates high peak flows in the streams, which can displace aquatic flora and fauna and lead to bank erosion. Trees' leaves and needles have a high surface area and can hold a tremendous amount of water, and the pervious soil and root system beneath the tree also stores large amounts of water. By retaining rainwater, trees and grass prevent it from becoming stormwater runoff. Multi-layered canopy surfaces of trees slow the impact of falling rainwater, and also help to reduce erosion. The stormwater runoff prevention model evaluates several parameters (perviousness of the soil; slope of the site; percent of canopy, grass, impervious surfaces; and amount of precipitation) in order to calculate the volume of stormwater retained by each site.

During a 2-inch storm event, Boulder's trees reduce stormwater runoff by 13.2 million cubic feet, which reduces the overall volume of water traveling through constructed stormwater management systems by over 12%. Modeling of a 0.5 inch storm event shows the same trees reducing runoff by 87%.

2. Energy Savings

Trees help to cool the air inside buildings by directly shading windows, roofs, and air conditioning units, and indirectly cool the air outside through evapo-transpiration (similar to the way a swamp cooler works). This leads to lower energy bills and reduced energy needs at the power plant. The energy savings model calculates the dollar amount and kilowatt hours (kWh) saved by this tree shade; it also determines the amount of carbon conserved (measured as "avoided carbon") when reduced region-wide energy consumption leads to reduced consumption of fossil fuel for power.

Trees provide an average of $58/year in energy savings for the average 1-2 story single family detached home in Boulder, or 950 kWh. This multiplies into approximately $1.65 million in annual savings in Boulder's residential areas. Energy savings were modeled only in residential areas due to the fact that in other land use categories, trees are generally too small and not close enough to buildings to provide measurable shade.

The large, mature shade tree on the south side of this home prevents solar energy from reaching the roof, windows, and walls of the structure, therefore making the air inside and surrounding it cooler and reducing (and sometimes eliminating) the need for air conditioning.

Trees in close proximity to cars, a major source of air pollution, are especially important.

3. Air Pollution Removal

Trees remove airborne pollution through the process of respiration. A tree intakes carbon dioxide, necessary for it's survival, simultaneously with several other air pollutants, through its stomates. Once inside the leaf these particles are disassembled into smaller pieces, some of which the tree can actually metabolize, while the others diffuse into intra-cellular spaces. Street trees are particularly important for this due to their close proximity to vehicles, the major source of air pollutants. The air pollution removal model takes into account the area in acres of tree canopy for each site and determines the amount removed of each of the following pollutants: carbon monoxide (CO), sulfur dioxide (SO_2), ozone (O_3), particulate matter less than 10 microns (PM10), and nitrogen dioxide (NO_2).

The existing tree canopy removes 220,000 pounds of airborne pollutants each year, valued at more than $525,000. This figure is based on alternative removal costs such as industrial scrubbers and avoided health care costs.

4. Carbon Storage/Sequestration

Carbon is the building block of all cellular life. Trees store carbon in their biomass (roots, trunk, leaves, and leaves), and carbon accounts for about half the dry weight of most trees. The amount of carbon stored increases as trees grow in size; while growing, they sequester additional carbon in order to generate new shoots and roots. Carbon is released again when trees die and decay, and a small amount is released each year when the leaves fall to the ground. Trees can be thought of as a "sink" for excess carbon in the atmosphere. Similar to the air pollution removal model, this model uses canopy acreage along with population age and trunk size to determine the amount of carbon stored in trees.

Trees store an estimated 110,000 tons of carbon and sequester about 2,000 tons annually within the City. In addition, kilowatt hours conserved by direct shading results in the reduction of approximately 1.6 million tons of avoided carbon emissions annually.

Regional Benefits of Urban Trees

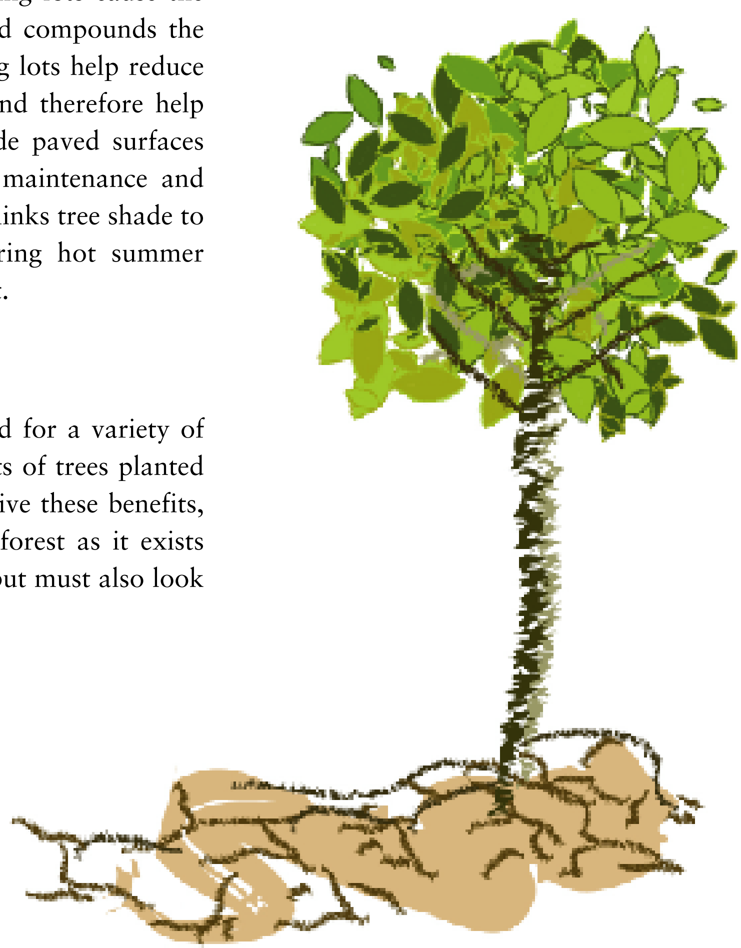
In April 2001, American Forests released the findings from the *Regional Ecosystem Analysis for Metropolitan Denver and Cities of the Northern Front Range, Colorado*. Average canopy cover for the entire region was measured at just 6%, while American Forests recommends an average cover of 25% (35% in suburban residential zones, 15% in urban residential zones, and 10% in the central business district). In order to increase average canopy cover in Boulder to realize additional benefits, more trees need to be planted, particularly in sparsely forested commercial and industrial sectors. Although these areas may never reach the canopy cover of residential areas due to the lack of available planting spaces, benefits of canopy cover can still be enhanced through proper species selection and placement.

Additional Unquantified Benefits

Other benefits of trees exist but have not been quantified by this study. For instance, the benefits of shading streets and parking lots are many. First, trees in parking lots provide a cooler place to park a car in hot summer months by reducing the air temperatures of the interior of the vehicle. Second, high ambient temperatures in parking lots cause the evaporation of volatile substances from vehicles and compounds the air pollution issue. Trees in and surrounding parking lots help reduce ambient temperatures though evapo-transpiration and therefore help reduce this type of emission. Third, trees that shade paved surfaces extend the life of asphalt or concrete and reduce maintenance and repaving costs. There is also anecdotal evidence that links tree shade to a reduced demand for water from turf grass during hot summer months, especially important during times of drought.

Conclusion

The Front Range's urban forest may have originated for a variety of different reasons, but we are still reaping the benefits of trees planted over the last 100 years. In order to continue to receive these benefits, we must not only work at maintaining our urban forest as it exists now, by replacing all removed trees with new ones, but must also look for new planting opportunities.



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