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# THE TREE PROJECT
## INTEGRATED URBAN ENVIRONMENTAL IMPROVEMENT THROUGH TREE SELECTION AND MANAGEMENT
## UPDATE – July 2007

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## About IES

The Institute for Environmental Solutions is an independent non-profit organization delivering proactive, technically sound solutions to salient environmental problems, without unwanted side effects.

An urgent need exists to develop, test, and implement cost-effective solutions to complex environmental problems. By addressing these issues with a multi-disciplinary technical approach, we can prevent waste and unwanted side effects, while optimizing environmental improvements, and reducing energy consumption and greenhouse gas emissions.

IES has identified critical multi-faceted environmental problems that are not being adequately addressed. We seek to engage a broad spectrum of participants in examining these problems on a project basis, and developing sound, cost-effective solutions.

## The Tree Project

The goal of The Tree Project is to identify how trees can be used to enhance energy and water conservation, carbon sequestration, and air quality. We are examining how the urban greenscape, through optimal tree selection, management and planting, can achieve significant improvements to the environment. As our population continues to grow, we want to help communities throughout Colorado and the Rocky Mountains optimize the environmental benefits trees provide while minimizing the costs.

The objectives of The Tree Project are to reduce air pollution (e.g., ozone / smog) and water and energy consumption while improving stormwater management and carbon sequestration by analyzing the benefits and costs of urban forestry. Planting trees and other vegetation has been proven to achieve multiple benefits. However, a multidisciplinary scientific analysis is needed to evaluate the tradeoffs between benefits and costs.

## The Tree Project Stakeholders

The Tree Project's stakeholders are vital to its success. IES believes communication and integration across technical, organizational, and social barriers are critical to developing the best solutions. Tree Project stakeholders include foresters, home builders and developers, landscape architects, nursery owners, tree and horticulture specialists, energy providers, water providers, community representatives, local, state, and federal government agency representatives, non-profit organizations, environmental consultants, volunteers, researchers, and teachers.

Participation in The Tree Project will yield many benefits for stakeholders. Foresters at municipal and state levels will be supported in their efforts to improve urban forestry such as preventing monoculture and minimizing maintenance costs. Builders and landscape architects will gain the resources to improve the quality of the service they provide their clients, while nursery owners will be rewarded through increased public awareness of the value of trees. Property owners and taxpayers will also reap benefits from the sound, comprehensive analysis The Tree Project will provide. Local government and community representatives will learn better approaches to community development using trees. Water utilities will obtain increased options for conservation. Energy provides will have new methods to reduce peak electric power demand and air pollution emissions. All community members will receive more environmental information to reduce pollution and mitigate global climate change.

## The City of Golden Tree Project Field Program

As part of a highly productive collaboration with the City of Golden's Department of Parks and Recreation, City Manager's Office and Mapping/GIS Department, IES completed a field data collection program in Golden June 18 – 20. The information we gathered will allow IES to develop multiple products for the City of Golden.

I-Tree UFORE

**Thank you City of Golden and IES Tree Project Field Teams!** Congratulations to our dedicated field teams on the completion of a successful three-day field program. Each of the four volunteer teams consisted of a forester, a data collector, and a recorder, who worked tirelessly in record-high temperatures to gather detailed information about Golden's urban forest.

The fieldwork included ground cover, tree, shrub and land use measurements (see Figure 1) on 114 1/10-acre plots randomly located throughout the city. Data were entered into PDAs as the teams visited each plot, and will be used as inputs for the Urban Forest Effects Model (UFORE), a U.S. Forest Service (USFS) computer modeling program which is part of the i-Tree software suite. Each plot was photographed. Plots included many different types of land use, such as homes, apartments, mobile homes, schools, commercial and industrial property, golf courses, vacant land, open space, highways, streets, and parking lots. Property owners were contacted to obtain permission to access private property before fieldwork began via letter and phone call.

We were very pleased with the enthusiastic cooperation of over 96% of property owners. Homeowners, in particular, were very interested in potential future improvements to their urban forest, in discovering which trees are best for the conditions in Golden, and in improving their environment.

Tools used in the various data analysis methods include computer programs (i-Tree [UFORE] and DesignBuilder) and field equipment (clinometer, compass, DBH tools, soil core, camera, manuals).

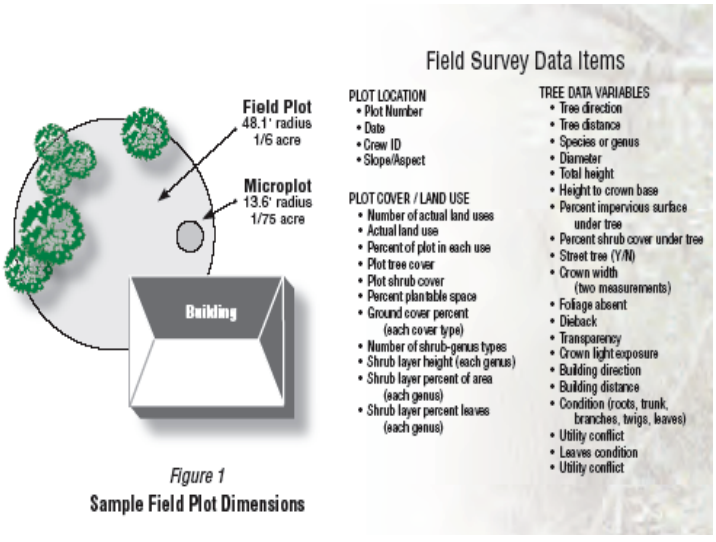


*Figure 1*
**Sample Field Plot Dimensions**

UFORE measurements will allow IES to model the *structure* (species makeup, quantity), *function* (environmental benefits: tons carbon sequestered and avoided, stormwater management benefits, energy conservation, and air quality contribution, as well as aesthetic benefits), and *value* (economic value of each benefit) of Golden's urban forest. This information will assist IES in developing a Strategic Planting Plan for the city that will improve tree planting practices, and may be applied elsewhere, especially in rapidly growing communities. The plan will be developed based on top-performing species in terms of net environmental benefits, along with recommendations from Colorado urban and rural foresters on the species appropriate to this area.

Concurrently with i-Tree measurements, preliminary data were collected to assessm the impact of trees on water conservation and energy conservation, part of IES' expanded field program discussed below. In addition, we distributed social surveys to homeowners for the social analysis on the relationship between income levels and barriers to tree planting and maintenance.

Future planting recommendations and resulting plans based on the results of the i-Tree and expanded analysis will allow IES to forecast environmental benefits based on specific tree species in terms of air quality improvements, carbon sequestration, stormwater benefits and energy and water conservation.

Expanded Field Study

IES has made significant progress in the expanded Tree Project field study since February. This more detailed analysis will be combined with the i-Tree results to provide a thorough assessment of energy conservation in this region as well as ground breaking work on the ability of trees to conserve water in various landscapes under different irrigation regimes.

***Trees and Water Conservation Analysis Pilot Test***

There is a general assumption that some trees consume water competitively when sharing the landscape with other vegetation, but the overall impact of trees on water consumption in the urban Front Range is unknown. To gain a better understanding of the dynamic interaction of trees and water consumption, IES initiated a multi-tiered research program which focuses on the effect of trees on soil moisture.

The first data set in this study was assembled during three days of fieldwork in Golden. Plots were selected for this Trees and Water Consumption pilot test from among those already in use for the UFORE model. To be included, a plot needed to have grass or grass-and-herb groundcover which was consistent across the entire plot and to be divisible into two portions: one with trees and one without, where the treeless portion extended at least three crown radii away from any tree. Each plot was assessed for its usefulness for the Trees and Water Consumption study. Wherever a plot met the selection criteria, landscape characteristics were recorded and a soil sample was collected from both the treed and treeless portions using a 15- x ¾-inch metal soil sampler. These soil samples were later weighed, dried, then weighed again to determine the moisture content of each. The result of this pilot test is a series of soil moisture data for sites with trees and without, which can be further divided by tree species and other characteristics. The same procedure was repeated on supplementary sites in Washington Park, Denver, to bring the total number of sites up to 20. This information is being used to design a

larger, more sophisticated experiment which will allow The Tree Project to answer some of the questions on trees and water consumption in Colorado.

### *Trees and Energy Conservation Analysis*

The purpose of the energy component of The Tree Project is to analyze the impact of trees on building energy use. To formulate the energy experimental design and analysis, IES consulted with an EnergyPlus program developer, several of our Institute Associates, and experts at NREL. DesignBuilder – a user friendly interface for EnergyPlus – was chosen as the primary tool for analysis. Working with a statistical consultant, we chose to model a representative sample of the City of Golden's buildings. Buildings of different types were chosen to evaluate energy consumption for different users:

- Six residential structures, including one apartment building
- Three commercial buildings
- Two institutional buildings

Each will be modeled three ways:

- Actual structure and groundcover
- With no trees
- With optimal tree cover

For each building, dimensions of the walls, windows and doors as well as tree data such as distance and direction from the structure, crown dimensions, species and an exposure value of the tree's shade were recorded. All the selected buildings were also associated with i-Tree plots.

### *Social Issues*

The goal of our social analysis is to identify reasons why some neighborhoods are well canopied while others are not, and specifically to address the challenge of limited tree canopy in low income neighborhoods. We consulted with Sabrina D'Agosta, City of Golden, to select an appropriate survey method. Each data collection team had copies of the survey either to fill out if a resident was available or to leave behind with a stamp-addressed envelope. Many plots were not associated with a structure. Of those that were, few people were home during the day. We hope to survey at least 380 residents to achieve a statistically accurate representative sample of the City's population and demographics.

Analysis To Be Done

### *I-Tree UFORE*

I-Tree data will be sent to the USFS for input into a report-writer program that will generate values based on our field measurements for the following categories:

- Air Quality – Hourly amount of pollution removed by the urban forest, and associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter.
    - Biogenic Volatile Organic Compound (BVOC) air pollution emissions – Relative impact of tree species on net ozone and carbon monoxide formation throughout the year.
- Energy – Effects of trees on building energy use.
- Carbon – Carbon dioxide ($CO_2$) sequestered and avoided (i.e., a reduction of power plant emissions due to tree shade impact on energy use)
- Tree pollen allergenicity index
- Pest impact potential

***Trees and Water Conservation Ongoing Research Program***

Some trees, such as cottonwoods, aspens and willows, are generally recognized as high water users. However, the shade trees provide may reduce the rate of evapotranspiration across the landscape. Property owners and professional landscape managers may thus be able to reduce their water consumption by taking advantage of tree-canopy shading. Trees are also adaptable and able to survive with varying, sometimes limited, amounts of water. Therefore, increasing the number of trees in the urban Front Range and other areas of Colorado (eastern plains and mountain communities) and the Rocky Mountains may or may not require additional water for maintaining healthy landscapes. New and growing communities, and rural towns with limited tree populations have the potential to conserve significant amounts of water used for irrigation of landscape. Given the high level of interest in tree planting and the myriad benefits trees provide, it is important to objectively evaluate their impact on water consumption.

Throughout this summer (2007), IES is investigating how trees affect total water consumption by analyzing the moisture content of soils shaded by tree canopies compared to those without tree cover. Daily soil moisture data will be collected at four locations (two each for the treed and treeless sides) on sixteen plots for two weeks. Other landscape characteristics, such as tree species and soil type, will also be recorded. Plot groundcover will be composed of grass or mixed grass/herbaceous plants and the entire plot must be irrigated under a regime that allows soil moisture to drop below field capacity for at least part of every day. The tree under which the tree-side sample is collected must be a mature tree. Water inputs into each plot (precipitation and irrigation) will be gauged. Solar irradiance will be estimated from regional weather data.

Once-daily soil moisture measurements will be supplemented by a near-constant stream of data from one special plot fitted with sensors to measure soil moisture by electrical conductivity. This equipment, which can be moved to generate time-series data for one site after another, will yield a comparison of the soil moisture response over time to individual irrigation or precipitation events between treed and treeless sites.

With daily soil moisture data and the time-series data, The Tree Project will have the information necessary to address important questions on trees and water consumption. The goal of the Trees and Water Conservation research program is to inform property owners, and landscape and tree professionals about the overall impact of trees on water consumption and how the impact varies with landscape characteristics like tree species and soil type.

### *Trees and Energy Conservation Analysis*

The structural and tree data collected in June will be entered into the energy simulation software program, DesignBuilder. Once all of the structures' specifications are entered appropriately and to the greatest extent of detail possible, the program will use the EnergyPlus calculation engine to simulate each structure in each of the three situations noted above. We will then interpret the data, charts and graphs produced by the software, to determine the impact trees have on energy consumption in a building. A pyranometer will be used to take measurements of different species canopy opacity to create a more realistic model that will be able to simulate trees at different stages of foliage and maturity and the resulting energy demand of the structure. All of the data combined will be used to analyze the sample to determine the potential building energy conservation benefits of increased tree planting.

### *Social Issues*

Ten surveys were completed during the data collection in June. IES has identified various additional methods of approaching residents of the City of Golden, of all demographics, to complete the survey and analyze the data by the end of 2007.

### *Quality Control*

- i-Tree – 6 plots were independently retested to provide an accurate error calculation
- Consultant assistance – Andy Bardwell, Ph.D., statistician and mathematician will advise on statistical aspects of The Tree Project.

Works in Progress

### *Carbon Credit Research – Community forestry as greenhouse gas offset*

Awareness about the climate "footprint" of individuals and businesses is growing rapidly. Many large greenhouse gas (GHG) producers such as coal-fired power plants and other industries are seeking to offset their GHG yield while people interested in preserving or expanding natural areas, especially forests, would like to be compensated for the carbon-offset function that their land provides. Besides sequestering carbon (as in the planting of new trees), a project may qualify as an offset by preserving a doomed carbon sink (e.g., South American rain forests) or by preventing the release of GHGs. In Colorado, the Rocky Mountains, and the high plains, a project might legitimately offset GHGs through:

(1) The sequestration of carbon by growing trees
(2) The shading of buildings and moderation of local climate which may reduce energy demand and GHG emissions at power plants
(3) Changing tree management practice to increase net sequestration across the urban forest.

By conducting impact studies using our accumulated understanding of community forestry, we hope to assist communities, companies, and organizations in designing and registering effective greenhouse gas offset projects. There are at least three ways for a new urban forestry project to be entered into the GHG market.

Many offset projects are listed on the Chicago Climate Exchange (CCX) [see table below]. Smaller projects (less than 10,000 metric tons offset) are listed indirectly through aggregators. Once an offset project is listed, the environmental benefit of the sequestration of carbon by the new trees can be purchased by other entities registered with the Exchange. To be registered with the CCX, an urban forestry project would need to be verified by one of the Exchange's approved verification services (for a fee). Forestry projects registered with the CCX must be demonstrably permanent, which may require statutory protection of the trees. Carbon offsets have been traded for $1 to $5 per metric ton.

An organization or community undertaking a community forestry project might also offer to retire carbon offsets on behalf of the local energy utility. The terms of this sort of arrangement would be negotiated between the municipality and the utility.

Finally, urban forestry projects could enter the carbon market through a private carbon neutralizing organization. Under these arrangements, the neutralizing organization buys and sells carbon offset units at a predetermined price. Typically, forestry offset projects are verified by the neutralizing organization, though some may require third party verification. The carbon offset achieved through an urban tree project's impact on energy demand might also be counted.

IES is investigating how to facilitate the identification, design, and implementation of effective carbon offset projects. The expertise in energy and urban forestry modeling gained may be applied in designing and marketing municipal forestry projects as carbon offsets.

| **Option** | **+** | **-** |
|---|---|---|
| City project (no transaction) | Simple. No exogenous standards. Good PR. | City would bear total cost (operation and publication) |
| Utility/city partnership (utility offset project) | Fairly simple. No exogenous standards. Good PR for utility and city. Utility shares cost. | Urban forests reduce energy demand (utility buy-in?). |
| Private carbon neutralizing organization offset project | Could potentially count energy savings. Flat rate paid for carbon sequestered. Wide publication; good PR. Few restrictions. | Must apply. Some standards (i.e., may require verification). |
| Chicago Climate Exchange offset project | Best regarded and most widely known. | Strict standards. Requires verification. No mechanism for trading offset from reduced energy demand. |

### *Model Urban Forest Ordinance*

To write and publish an environmentally beneficial tree ordinance, IES has conducted an extensive examination and cross comparison of six Colorado Front Range communities' tree ordinances – Denver, Westminster, Boulder, Aurora, Castle Rock and Fort Collins. IES met with city staff members from the planning and forestry departments to obtain feedback on the City of Golden's priorities for a model ordinance. IES has begun an initial draft of the model street tree ordinance which incorporates these priorities.

### *Software Development*

A user-friendly landscape design software tool is planned for Phase 3 of The Tree Project. This tool will assist homeowners, developers, landscape architects, foresters, city government and planners to use trees to optimize environmental improvement through an online graphical interface that allows the user to visually display their unique property and manipulate it with recommended species for specific environmental benefits.

### *School Programs*

At the request of an elementary school in Golden, IES is working on a proposal to evaluate the environmental impact of local pollution sources (such as highways) near a school, and determine how trees can improve the local environment. This will serve as an educational pilot project that will inform residents, students, and local officials on the value of our urban forest beyond aesthetic benefits.

### *Tree Science Database*

IES proposes to create an electronic database similar in style to 'wikipedia.com' to offer the stakeholders and the public access to scientific data on tree research, programs, and projects. This will allow other experts to contribute additional publications, articles, or other current information to the e-library. The concept is to allow the dissemination of information to the general public and sharing of information among stakeholders and researchers while gaining supplemental information from additional sources. Contributors can submit information and articles in a submission page that will be carefully reviewed by IES staff members and experts. Qualified work will then be filed within the database.

***Comments and questions on The Tree Project are welcome. Please visit our website:***
***www.instituteforenvironmentalsolutions.org/treeproject.html***
***Or e:mail: Solutions@i4es.org***

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