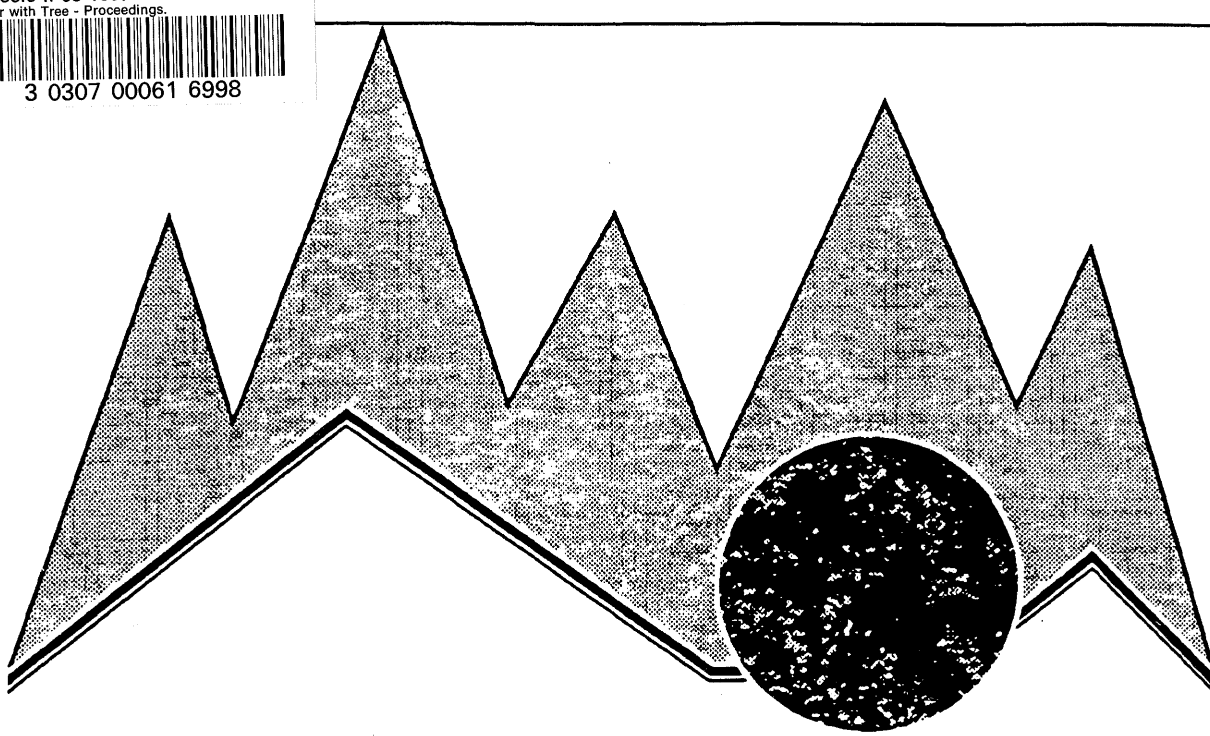

Power with Trees

CREATING ENERGY EFFICIENT LANDSCAPES

symposium

PROCEEDINGS

Held on March 11, 1995

Minneapolis, Minnesota

Minnesota Department of Natural Resources
ION OF FORESTRY
aul, MN

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sponsored by

UDSA Forest Service Northeastern Area
State & Private Forestry
Urban Forestry Center for Midwestern States

Minnesota Department of Natural Resources
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- Foreword -

Dear Reader:

'If you don't like the weather here, just wait a minute, ... it will change,' is the casual prophecy echoed by many citizens of the Midwestern and Northeastern states during both pleasant and uncomfortable weather. This region of the country is known for extremes in temperature, and sometimes quick and drastic changes in humidity, precipitation and wind speed. While influencing the weather is beyond our control, ameliorating the extremes in temperature and climate and reducing energy costs within a localized setting can be achieved by planting and caring for urban trees and forests.

Power With Trees is a collection of papers expressing how trees and urban forests are an integral component of the ecosystem, providing a livable habitat for plants, animals and humans. These papers evolved from the *Power With Trees: Creating Energy Efficient Landscapes Symposium,* held in conjunction with the Energy Efficient Building Association's 1995 Excellence in Housing Conference. Included in this collection are scientific papers discussing how properly planned, planted and maintained trees can influence wind speed, wind direction, humidity, air temperature, soil temperature, soil and moisture, and airborne pollutants.

Urban areas can learn a lot from their rural cousins as far as planting trees in a design that is beautiful, and yet functional from an energy conservation point of view. According to a scientific study developed by American Forests in cooperation with the Environmental Protection Agency, 'cities are five to nine degrees hotter than the surrounding countryside and can be described as heat islands. The heat islands cause people to use billions of dollars in energy for cooling annually.' *Power With Trees* provides examples of successful partnerships designed to assist local communities in implementing cost saving, energy efficient landscape designs. These examples include national efforts such as American Forests' 'Cool Communities' program, the USDA Forest Service Chicago Urban Forest Climate Project, and USDA Forest Service National Agroforestry Center, as well as regional efforts such as the Minnesota Department of Natural Resources' Minnesota ReLeaf and the partnerships exemplified by Midwest Power, Trees Forever and the Twin Cities Tree Trust.

Energy conservation is just one of the myriad benefits that trees and forests provide to cities and communities across the country. A healthy urban forest contributes to a sense of community pride and ownership, relieves the stress of urban life, provides privacy and a sense of serenity, softens harsh built structures, and adds nature to our cities and towns. In addition, trees reduce air pollution, conserve water and reduce soil erosion, reduce noise pollution, create wildlife and plant diversity, increase property values and can increase the economic vitality of a community by creating a more pleasant atmosphere for businesses, tourism, and homeowners.

The greatest testimony regarding the need for trees in and around communities is that people like trees! The amount of time citizens spend caring for the landscape of their own yards in addition to the time they volunteer to community greening efforts attests to this fact. In addition, as demonstrated in the papers outlined in *Power With Trees*, the benefits of maintaining healthy forests far outweigh the costs.

Power With Trees is made possible by the sponsorship of the USDA Forest Service Urban Forestry Center for the Midwestern States, Minnesota Department of Natural Resources, Division of Forestry, Energy Efficient Building Association, Inc., United Power Association, Northern States Power, Midwest Power, and IES Utilities Inc. Special thanks goes to Peggy Sand, State Urban & Community Forestry Coordinator, Minnesota Department of Natural Resources for her tireless efforts in promoting the science and understanding of urban forestry including the coordination and organization of the *Power With Trees* symposium and editing the symposium proceedings.

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Power with Trees

CREATING ENERGY EFFICIENT LANDSCAPES

contents

ENERGY CONSERVING LANDSCAPE STRATEGIES

Peggy Sand, Minnesota Department of Natural Resources

INTRODUCTION

Across the country, communities are embarking on major tree planting projects to improve their environment. Much of the effort is driven by evidence which supports the use of trees to conserve energy and provide environmental benefits. But, too often people's desire to do the right thing is not met by an ability to do it right.

This paper is a checklist of the most basic factors a person needs to know in order to effectively use trees and site buildings for energy conservation.

Obviously, people have many objectives when they locate a building on a site and plant around it. But, among the many important considerations is orienting the building and planting trees to conserve energy. To the extent that energy conservation is the goal, people have an obligation to know how to maximize the benefits and avoid doing it wrong. With this in mind, this paper should serve as a checklist of the most basic factors a person needs to know in order to effectively use trees and site buildings for energy conservation.

Up until a few years ago nearly all the planting for energy conservation information was coming out of the air-conditioning dominated climates of California, Arizona, and Florida. But, a homeowner in the upper midwest typically spend about ten times more heating than cooling a home, which means that reducing heating energy use is a much bigger target at which to aim if the goal is to reduce total energy use.

ENERGY USED IN DEVELOPMENT & BUILDINGS

To be truly energy efficient, people should look beyond the design of the individual building and site to the idea of whole development energy accounting. In most places, such as Minnesota, although a lot of energy is used to heat and cool buildings, significantly more energy is used and most emissions result from transportation. Plans for site development need to assess how much energy goes into mining and manufacturing the resources and constructing the roads, sewers, and utility systems as well as the energy needed to run them. Thus, broader development patterns should be evaluated and modified to improve the overall energy efficiency.

Communities and individual buildings should be located and designed to best take advantage of their natural environment and the energy conservation benefits and challenges that are givens.

Summer Energy Use

A first step is to look specifically at the way climate affects building energy use. In the summer, the sun rises in the northeastern sky, passes nearly directly overhead at midday, and sets in the northwest. This means that in summer most solar energy hits the east and west walls. Because of solar angles, when a home is well-insulated, in summer nearly half of the unwanted heat gain is from solar energy primarily through west and east facing windows. The high angle of the sun, particularly in June and July, significantly reduces the amount of solar gain through south windows. A roof overhang or awning immediately above a south facing window can virtually eliminate summer solar gain through south windows.

In fact, in a well insulated Minnesota home less than 5% of the solar gain is through the roof and walls combined. More electricity is used in Minnesota late in the afternoon on the hottest days of the year. When this peak demand exceeds the local generating capacity, electricity must be purchased from other utilities or new power plants must be built. To avoid these costly situations, reducing energy use in the afternoon, when the sun shines on west sides of buildings is most important.

On hot days a well vegetated environment around a home helps cool the environment and the home. When a building is surrounded by hard surfaces, the pavement around absorbs the solar energy throughout the day and continues to heat the environment through the evening. This is a major cause of the summer heat island affect in cities.

Winter Energy Use

In contrast, in the winter, the sun rises in the southeast, barely gets above the southern horizon, and sets in the southwest. The most solar energy received by any wall or window at any time in the year is hits the south side in winter giving significant amounts of free solar energy through south facing windows. In winter, the biggest loss of heat is due to air infiltration (or air exchange) in large part in the Midwest because of the strong northwesterly winter winds. Therefore, windbreaks can be among the most effective ways to reduce annual energy use.

SELECTING AND LOCATING TREES FOR ENERGY CONSERVATION

The most effective actions in using trees for energy conservation can be condensed into five basic strategies. Which of these are most important and exactly how they are applied will depend on local conditions. The following discussion will state the basic planting principle and related site planning approaches, a slogan that can be used to help people remember the key ideas, the primary criteria which should be used in selecting and locating trees.

Shade West and East Windows

To most effectively reduce air-conditioning use, shade west and east windows by clustering houses with their east and west sides close to each other and by shading exposed west and east windows with trees. Although the solar gain through east and west windows is the same in most climates, the advantage of reducing peak electrical energy use in late afternoon results in priority tree planting reflected in the slogan "west is best".

- Give highest priority to planting shade trees directly west of west windows.
- Plant trees east of east windows as second priority.
- Select a tree that can be planted within twenty feet of the window and will grow at least ten feet taller than the window.
- Select trees that are strong, resisting disease and pests and damage from storms; and that will grow vigorously under local site conditions.
- Select a tree with dense foliage, as broad in form as space permits. As shown in Figure 1, a broad crowned tree creates a better shadow than pyramidal one of the same height. If using a linden select an American Linden (*Tilia americana*) rather than the narrower Greenspire (*Tilia cordata 'Greenspire'*) or Redmond Linden (*Tilia x euchlora*).

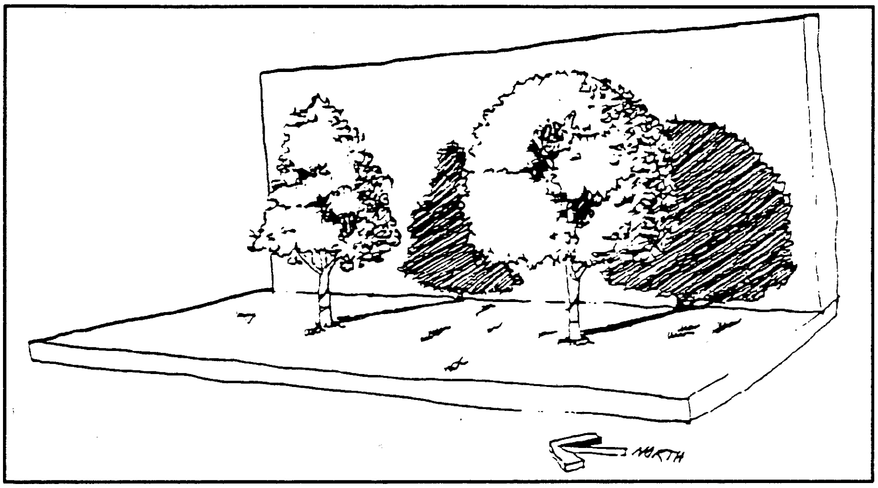

Figure 1. A broader crowned tree (right) casts a much larger shadow than a pyramidal shaped tree of the same height (left).

In summary, shade west and east windows with other homes clustered nearly or by selecting tall, broad, and dense trees located reasonably close to the windows.

Avoid Trees South of Windows

Since more solar energy hits south facing windows in winter than in summer, in most climates annual energy savings will be improved by avoiding trees south of windows. Furthermore, buildings should be designed and oriented so that the amount of window area facing south is maximized in order to take advantage of the free solar energy. That is, during the months when a home needs heat, the slogan should be followed to "**let the sun shine in**".

Specifically, the worst place to have a tree from an energy-savings perspective is out in the yard south of a home. Trees should be avoided out in the yard south of a home, since the sun's angles cause the shadow of the tree to totally miss the home during the summer months and to always fall on the home during the winter months. (See Figure 2.)

- To avoid shading south windows, any trees south of the home should be located at least twice their mature height away from the house.
- Remove the lower branches of any trees on the southwest or southeast sides of the home to allow more winter sun through.

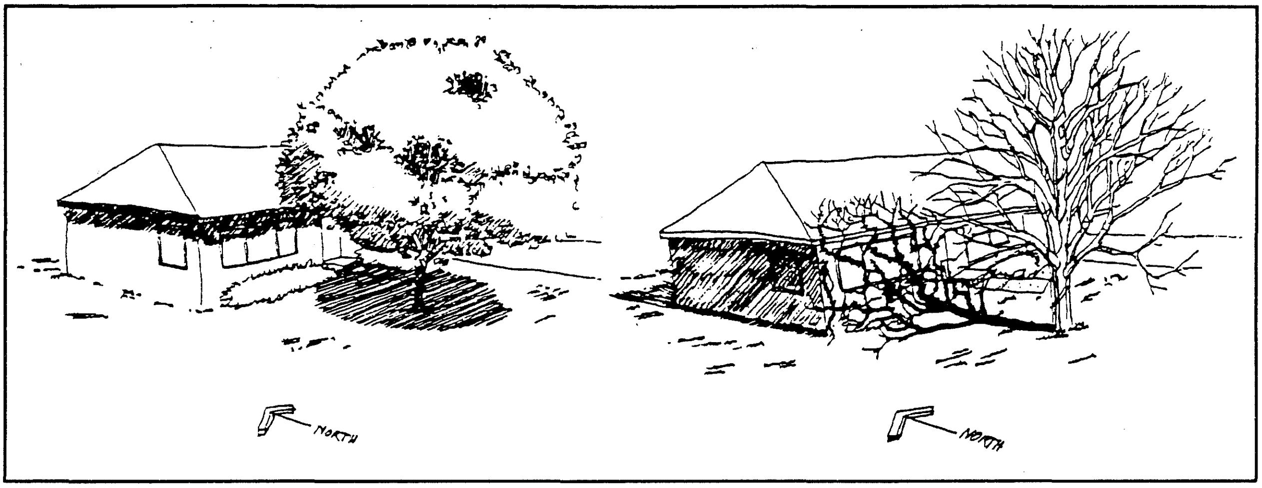

Figure 2. The shadow of a 25-foot tall tree located 20 feet south of a home completely misses the home in summer (left). The same tree shades the picture window through the winter blocking free solar energy (right).

People may say that using a deciduous tree to the south is all right. But, tree trunks and branches get bigger with age. Even without leaves, a larger tree will block 30-50% of the solar energy. Species also vary in their density, from denser maple to sparsely-branched walnut and coffeetree. Trees near south facing windows should be selected which are "solar friendly" with denser foliage during the warm months and with sparse branching structure during the colder months.

- Use a "solar friendly" tree which has dense foliage during the hottest times of the year, loses its leaves in fall as the heating season begins, and has sparse winter branches. Give preference to cultivars from northern seed sources.

In summary, design and site buildings to maximize south facing windows, avoid trees south of windows and use only solar friendly species to the southeast and southwest of windows.

Create Windbreaks

Where winters are long and windy, the most valuable way to reduce annual energy use is to create windbreaks. Contrary to some popular illustrations, no evidence supports that shrubbery around the foundation of an insulated building will save energy. Instead, inspiration can be found in the prairie region where windrows and shelterbelts have been used for decades in which tall trees guide wind "**up and over.**" Through windbreaks a large area of calm air is created behind the trees, extending downwind at least ten times the height of the windbreak.

Trees are the perfect windbreak because they gently filter and absorb the wind without creating turbulence. And, because of the significance of air infiltration in building energy use, windbreaks are the most important way to save energy, particularly in the wide open areas in the midwest, which are among the windiest places in the country.

- Select windbreak trees which are evergreen and which will have branches from ground level to a height at least twice as tall as the building being sheltered.
- Select trees that are best adapted to the site's growing conditions so they will be tall, yet dense.

Windbreak trees need to be placed upwind and spaced close enough together to create a dense screen, yet with enough space between trees to promote tree health, growth, and the retention of their foliage to the ground.

- Plant rows or continuous clusters of trees upwind and perpendicular to the primary wind direction - usually running along the west and north sides of the property.
- Where enough space is available to plant a multiple row shelterbelt of evergreens spaced about 20 feet apart and deciduous trees at greater spaces.
- Locate the inside of a shelterbelt on a very open site at least 50 feet from buildings and driveways to avoid snow drifting problems, even if it is set back on the other side of the road.
- Space trees close together, yet far enough apart to allow the sun to reach the lower branches, particularly of the outside rows.

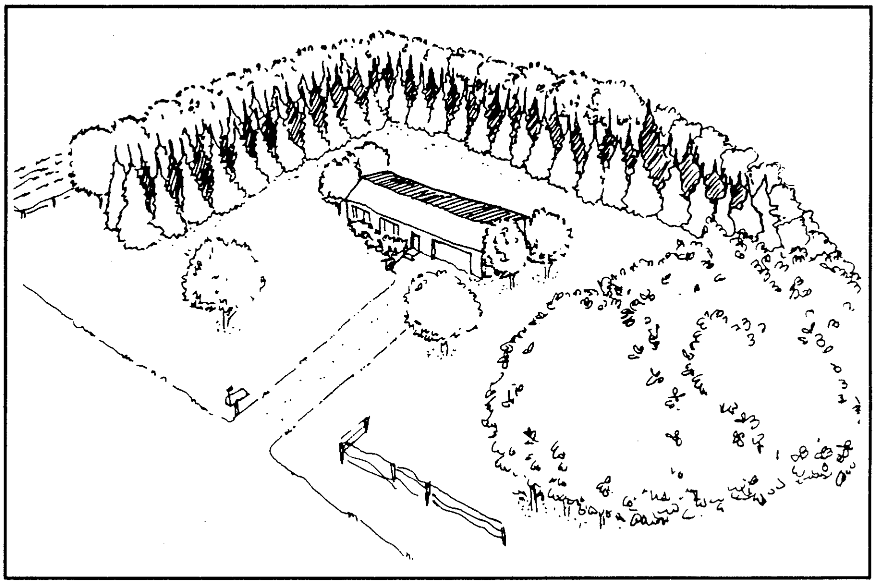

Figure 3. This large rural home site has a shelterbelt to the west and north, trees shading west and east windows, and a preserved woodlot to the east.

Residential lots of about one-quarter acre or more can incorporate a one or two row windbreak by planting evergreen trees in sunny locations (away from other large trees) in rows or groupings spaced about ten feet apart. Where the developer cooperates, a whole neighborhood of homes can be shielded with a single well-designed shelterbelt or a series of windbreaks. Also, a community shelterbelt can be designed to protect a prairie town.

In summary, create windbreaks to shelter homes and neighborhoods using tall dense trees well spaced.

Shade Air-Conditioners

An air-conditioner runs more efficiently if its in a cooler environment. The most obvious approach is to place air-conditioners against the north side of the building and take advantage of that shady, cooler facade of the building. But alternatively, trees may be effectively used to shade air-conditioners and thereby "**keep it cool**".

If the air-conditioner is not along a north facing wall, ideally, it will be in a grove of small to medium size trees, which create a cooler surrounding microclimate, but which also allow good air flow around the unit. Shrubbery and tree branches should be kept at least three feet from the unit to allow good air flow.

- Locate air conditioners away from south windows and shade them with trees.

The same "keep it cool" concept can be applied to patios and parking lots. People are more likely to turn up the air-conditioner if their patio or car is out in the cooking sun.

In summary, shade the air conditioner with the building and with trees on the sunny sides, while keeping shrubbery and tree branches away.

Increase Canopy Cover

When traveling over a community in an airplane and looking down, the trees that hang over homes, roads, and the ground are what is called the canopy cover. A downtown will be obvious because it is all buildings and pavement and has no trees. Urban foresters would say that such an area has 0% tree canopy cover. Older neighborhoods typically have 20-30% canopy cover and a densely wooded park may have 90% canopy cover.

Research strongly suggests that most environmental benefits of trees increase proportionately to increases in the volume of trees throughout neighborhoods. The benefits apply in winter as well as summer. An area with over 50% tree canopy cover will have half the winter wind and, in cities, will avoid much of the summer heat island. Furthermore, because chemical interactions in the air depend on air temperature, cooler summer temperatures means less air pollution. Thus, the final strategy is to increase tree canopy cover as reflected in the slogan "**the more the merrier**".

A first target is to maximize canopy cover in neighborhoods.

- Achieve at least a 50% tree canopy cover by planting deciduous and evergreen trees throughout the neighborhood and in every yard.
- Give priority to trees which will reach at least 30 feet tall.

Second, whenever sufficient infrastructure (soil, water, and drainage) can be provided to assure tree health and growth, use trees to maximize shading of pavement. In these cases, such as an apartment building parking lot which previously had no trees, soil and planting areas must be thoughtfully prepared and trees carefully selected which will best tolerate urban conditions with minimal maintenance demands. This goal is reflected in a policy in Sacramento, California where 50% canopy cover over parking lots must be achieved within about 10 years of construction and planting.

Third, throughout each community, tree volume should be maximized, increasing leaf surface area to reduce the heat, and increasing the tall canopy cover and evergreen foliage to reduce winter wind. Therefore, tree size and longevity should be increased in green areas conducive to vigorous tree growth. This means extensive planting and tree care in yards, parks, stream corridors, and vacant lands. It also means creating more adequate space for healthy downtown trees and street trees.

SMALL TREES AND LARGE TREES

Before concluding, some additional points are warranted about the relative value of smaller and larger trees. Cost-effectiveness evaluations will invariably shows that planting smaller less expensive stock provides the greatest benefit at the least cost. Typically, in major tree planting programs, it makes most sense to use small to mid-sized potted trees.

But, in virtually all cases, most benefits accrue from larger mature trees and efforts must be undertaken to keep them. Therefore, not only is strategic tree planting important, but just as important is strategic tree preservation and care. When communities are so fortunate to have larger trees, the most effective way to achieve energy conservation is to assure the long life and health of the existing urban forest.

- Preserve and care for existing trees and forests near neighborhoods.

CONCLUSION

In conclusion, the design of communities and individual properties as well as the selection and location of trees should contribute towards energy conservation. Each project should respond to local climatic conditions and use the land and trees wisely to optimize environmental benefits. As shown in Figure 4, a home can be well-designed to optimize both beneficial solar gain and tree cover.

Specifically, people can employ the power of trees by applying these basic strategies to conserve energy: 1) shade west and east windows, 2) let the sun shine in by maximizing south windows and avoiding trees south of windows, 3) create windbreaks, 4) shade air conditioners, and 5) increase tree canopy cover. And by these wise approaches, everyone involved will take a significant step towards creating sustainable communities.

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Ms. Sand has conducted research, written publications, and directed a statewide matching grant program - all aimed at increasing effective use of trees for energy conservation. She is a registered landscape architect who is now Minnesota's State Urban & Community Forestry Program Coordinator.

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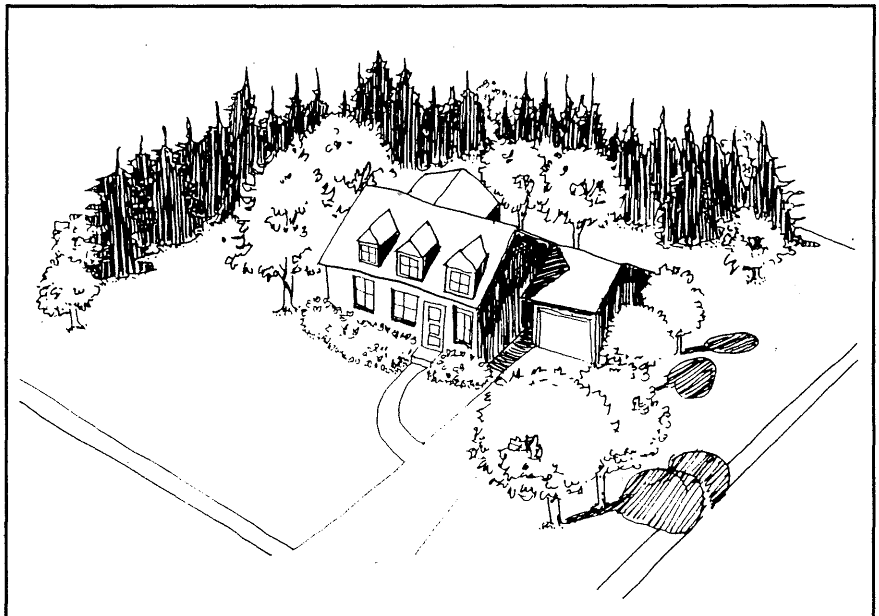


Figure 4. This solar-oriented south-facing home has trees strategically shading west and east windows as well as shading the driveway. Continuous evergreens to the north and west will block winter winds.

THE EFFECT OF VEGETATION ON RESIDENTIAL ENERGY USE IN ANN ARBOR, MICHIGAN

Geoffrey Lewis, University of Michigan
and Robert J. Laverne, ACRT, Inc.

INTRODUCTION

Energy conservation continues to be a major concern for most utility companies and consumers. While the oil embargo of the 1970's highlighted the limited supply of energy source natural resources, concern for the environment, including global warming, has renewed interest in energy conservation.

Combustion of fossil fuels contributes to carbon entering the atmosphere. Considerable debate surrounds the degree to which increased carbon in the atmosphere contributes to global warming, but the fact that atmospheric carbon is rapidly increasing cannot be disputed. International demand that the United States recognize its role in creating this problem has led to the Clinton administration's Climate Change Action Plan. This plan calls for rolling back greenhouse gas emissions to 1990 levels by the year 2000.

> *Until now, much of what is known about the energy-conserving benefits of trees has been based upon computer simulations. This project is breaking new ground by trying to measure the impact of trees in real neighborhood settings.*

Tree conservation, planting and maintenance can play a multi-faceted role in energy conservation and control of atmospheric carbon. All trees store or "sequester" carbon, and expansive natural forests serve as carbon sinks. Depletion of tropical rain forests has resulted in a loss of carbon storage capacity and a release of large amounts of stored carbon. In addition to simple storage, proper placement of trees in developed areas can provide cooling shade which results in less electricity required to operate air conditioners and therefore less fossil fuel burned at power plants and less carbon released into the atmosphere. Reducing peak energy demand benefits utility companies and lowers utility bills to homeowners.

Trees also indirectly contribute to energy conservation through shading of hardscape and dark surfaces, such as parking lots, which absorb sunlight and re-radiate the energy as heat. In addition to providing shade, trees move water vapor into the air through evapotranspiration, which makes trees particularly effective at diminishing urban heat islands.

In winter months, properly placed trees continue to provide direct and indirect benefits through reducing heating requirements for buildings. Trees oriented perpendicular to prevailing winter winds and upwind from climate controlled buildings slow wind velocity and directly reduce infiltration. Individual tree crowns throughout the canopy, including hardwoods which have dropped their leaves, also break up wind patterns and indirectly reduce cold air infiltration. Improperly placed trees can be detrimental to energy conservation, particularly in northern climates where trees to the south of buildings may block beneficial solar gain during winter months. The placement of trees must consider the net impact on both heating and cooling requirements of buildings to achieve optimum levels of energy conservation.

The fact that trees can contribute to energy conservation is supported by research conducted primarily with computer generated models (Heisler 1991, Huang et. al. 1990, McPherson 1994). Less work has been conducted that seeks to quantify the effects of vegetation on energy use by studying actual residential energy consumption. This study conducted in Ann Arbor, Michigan by ACRT, Inc. and the University of Michigan was designed to take an important step in developing a methodology to measure and test the effect of urban trees on energy use.

The Study Site

The study site is a residential neighborhood in Ann Arbor, Michigan. The center of the study site is located at 42°17'07" north latitude, 83°41'10" west longitude, and the elevation at the site varies between 850 and 900 feet above sea level. The site was initially selected through inspection of aerial photography (October 1991 1:7,200 color infrared transparencies) which revealed three distinct levels of tree canopy closure within the same neighborhood. For the purpose of this study, the homes were grouped in three strata which correspond to high (stratum 3), medium (stratum 2) and low (stratum 1) levels of tree canopy closure.

Examination of historical aerial photography shows the site consisted of a natural woodlot and agricultural fields prior to development. In 1969, clearing of roads and house lots began in the woodlot and in a portion of the fields. The homes which occupy the original woodlot were built under the canopy of existing mature trees (stratum 3). The homes built in the fields during the late 1960's to the mid 1970's have benefitted from landscaping which included tree planting. Many of these trees are now approaching maturity and provide significant levels of shade to the homes (stratum 2). The remaining area was not developed until 1981, when most of the remaining homes were built. Some landscaping has been done around these homes, but the trees are immature and provide little shade or shielding from the wind (stratum 1).

METHODOLOGY

Introduction to Homeowners

In November of 1993 an introductory letter was distributed to all 142 homes in the study area. Included with the letter was a photocopy of an *Ann Arbor News* article (Branam, 1992) which publicized previous work conducted by the researchers in the community (Laverne, 1992) and the importance of trees in cities. The letter briefly described the objectives of the upcoming research and announced that researchers would be visiting homes in their neighborhood. This letter and the *Ann Arbor News* article proved to be quite valuable when it came time to visit homes on a door-to-door basis. By giving homeowners advance notice of the project, the amount of time necessary to describe the study face-to-face was reduced. More importantly, people seemed to be much more cooperative if they were prepared for a visit a short time in advance.

Within one week of the distribution of the introductory letter, door-to-door visits began. Discussions were kept under five minutes so as not to burden the homeowners. A second letter was distributed at this time which briefly described the benefits of trees to energy conservation. The letter also asked for cooperation in the form of permission for the researchers to access utility use information for their house from Detroit Edison and Michigan Consolidated Gas Company, and by agreeing to complete a brief survey with the researchers.

Most homeowners contacted during the first round of visits expressed an interest in the project and provided verbal commitment to cooperation. Those people who responded favorably frequently cited the first letter or the newspaper article as prompting their interest. Without it, some individuals commented they would never have opened the door when researchers came to visit. Homeowner participation was vital to the project, and a non-intimidating, informative yet brief introduction seemed to be a key element in gaining acceptance.

Encouraged by this level of cooperation from initial encounters with homeowners, the researchers reported back to officials at Detroit Edison and Michigan Consolidated Gas Company. Draft versions of the utility data release form and a survey designed to provide energy use profiles for individual homes were prepared. The utility companies were asked to review these draft documents and provide input on how they might be improved. The draft energy use survey was also reviewed by Dr. Greg McPherson and Dr. Gordon Heisler of the U.S. Forest Service, and Peggy Sand of the Minnesota Department of Natural Resources. The suggested revisions to the survey and release form were incorporated, and with the help of these individuals the methodology for the collection of field data was refined.

Distribution of Energy Use Survey

In early January 1994, a second door-to-door campaign was begun to obtain signatures on release forms and complete the energy use surveys. This also provided an opportunity to contact homeowners who were unavailable during the first round of visits. Of the total 142 homes in the study area 101 homeowners signed release forms and completed energy use surveys, 26 homeowners were unable to be contacted, and 15 homeowners declined to participate.

The survey was designed to gather information relevant to the formation of energy use profiles for the individual homes without requiring significant amounts of investigation or time from the homeowners. The most difficult variables to measure in this study are those associated with different energy use patterns of individual families. The survey can be broken down into two types of information: first, information related to significant energy consuming appliances, and second, information related to behavior which impacts energy consumption.

Examples of questions about appliances included:

- What is your primary heating fuel?
- How old is your furnace?
- Is your home air conditioned?
- What type of range/stove do you have?

Examples of questions related to behavior include:

- How many people currently reside in your home?
- What are your normal day/night winter thermostat settings?
- Do you close off rooms in your house?
- Do you leave a window cracked open for ventilation in the winter?

With few exceptions, the surveys were completed jointly between the homeowners and the researchers. This reduced the chance of interpretation bias by homeowners who did not completely understand a question. This also allowed researchers to gather other relevant information unique to individual homes but not necessarily included in the survey, for example the periodic increase in number of residents due to children returning from college.

Acquisition of Utility Data

Natural gas and electricity consumption data were provided by Michigan Consolidated Gas Company and Detroit Edison for the houses participating in the study. Data were reported by billing period between March, 1993 and May, 1994. Fifteen billing periods, each approximately 30 days in length were obtained for both gas and electricity. Data were examined by individual billing and were also grouped into heating and cooling seasons. Billing period end-dates determined the boundaries of the heating and cooling seasons in this study, with the heating season being defined to be from October 11, 1993 through April 12, 1994 and the cooling season extending from May 20, 1993 through September 15, 1993. The periods between heating and cooling seasons were considered to be transitional. Natural gas consumption was reported in hundreds of cubic feet (CCF), and electricity consumption was reported in kilowatt hours (Kwh). These units were then converted to British thermal units (Btu) and put on a daily basis (Btu/day) for comparison and analysis (1 CCF=100000 Btu, 1 Kwh=3413 Btu). The daily basis was used to remove bias due to billing periods having different numbers of days.

Measurement of Home-Shading Vegetation

To quantify the effect of vegetation on energy use it is first necessary to quantify the density of vegetation which casts direct shade on a building or shields a building from wind. Three variables determine whether shade is cast on a building by a tree: 1) the position of the sun in the sky, 2) the position of the tree relative to the building, and 3) the height of the tree.

The position of the sun in the sky is predictable for any time of any day. Charts which describe the solar path are available for a variety of latitudes (Figure 1). The path of the sun on a particular day determines which fixed objects will cast shade on a given point that day. Objects such as trees will cast shade on a building if they are tall enough and close enough. As the path of the sun changes each day and season, the shade patterns of trees and all other fixed objects change as well. The predictable path of the sun can be used to determine which trees directly shade a building on a particular day.

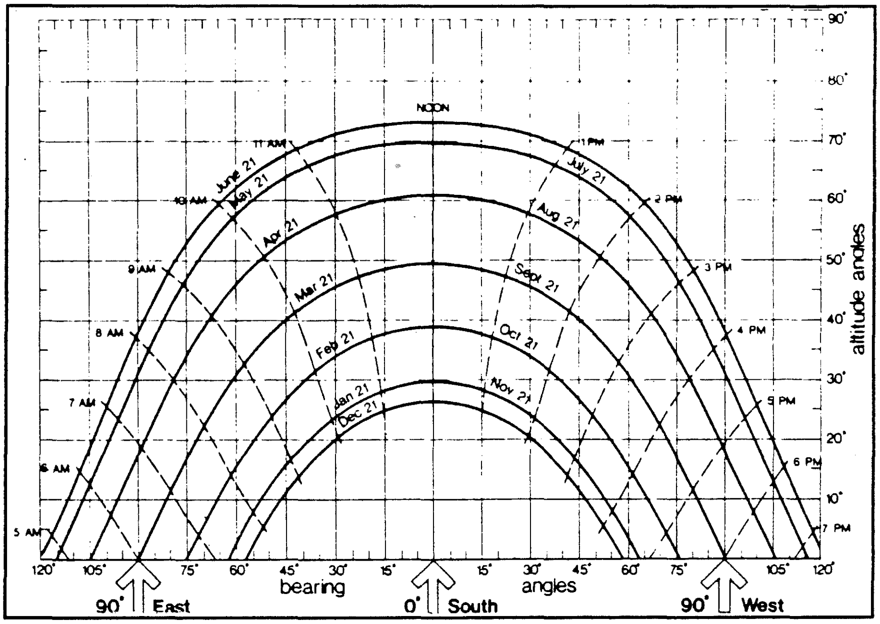


Figure 1. Solar path chart for 40° north latitude (from Mazria 1979).

The extremes of the solar path occur during the winter solstice and the summer solstice. At noon on winter solstice the sun will be farther to the south and closer to the horizon than on any other day during the year. As a result, the shadows cast by stationary objects such as trees will be longer at any given time than during any other day, and conceivably a tree may cast shade on a nearby building for only this single day during the entire year. Conversely, the sun will achieve its greatest height from the horizon at noon on the summer solstice. Shadows cast by trees at any given time on the summer solstice will be shorter than on any other day during the year, and conceivably the day of summer solstice may be the only day during the year that a tree does not cast shade on an adjacent building.

For this study, solar paths for days other than the extremes of the solstices were selected for several reasons. First, since the solstices represent the extreme limits of the solar path, days selected somewhat removed from the solstices will adequately represent seasonal conditions but avoid the extreme cases mentioned above. Second, previous studies, particularly those conducted by Dr. Gordon Heisler, used the dates of January 21 and July 21 to compare winter and summer conditions. A more convenient comparison of results between studies could be made by also using these dates for the study in Ann Arbor. Gathering data for only two dates provided information on summer and winter conditions within the time and budget constraints of the project.

The tools necessary for tracing a solar path in the field are: 1) a solar path chart for appropriate latitude (e.g. Figure 1), 2) a magnetic compass to determine horizontal position (azimuth), and 3) a clinometer to determine vertical position (elevation). As the path of the sun is traced, a type of spotting scope or crosshair is useful to assist in visualizing which trees intercept the solar path relative to the observer's position on the ground. A Suunto compass and a Spiegel Relaskop were mounted on a tripod for this purpose. The solar path was traced by using the compass to determine azimuth and the clinometer in the Relaskop to establish elevation. Using the eyepiece of the Relaskop as a spotting scope which follows the solar path, the researchers recorded the frequency with which the crosshair in the Relaskop fell on vegetation rather than open sky. Other objects such as buildings which intercept sunlight were also recorded. Solar paths for the summer and winter dates were traced in this manner from each facade of a building which would receive sunlight on that date.

The presence of vegetation was recorded along the solar path for angles of plus and minus 45 degrees from the perpendicular to the plane of each building facade. Considering points at angles greater than 45 degrees would have resulted in some points being counted more than once due to an overlap from the adjacent facade. The presence of vegetation at the crosshair of the Relaskop was noted at each 5 degree increment in azimuth for solar angles of 15 degrees or less from the perpendicular to a facade. The presence of vegetation was noted at each ten degree increment of azimuth for angles between 15 and 45 degrees from the perpendicular. For example, a house with a facade that faces due south (180 degrees azimuth) would have sample points examined for the presence of vegetation at the following azimuths: 135°, 145°, 155°, 165°, 170°, 175°, 180°, 185°, 190°, 195°, 205°, 215°, and 225° (Figure 2).

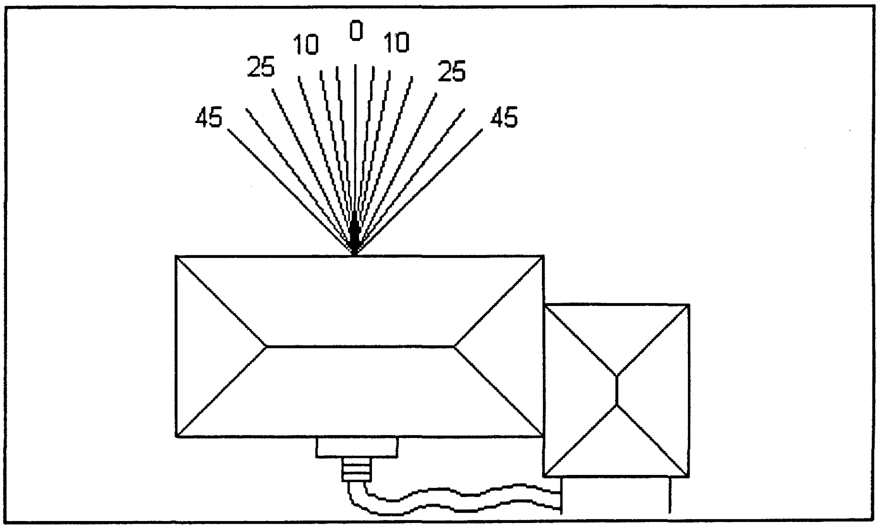


Figure 2. Angles at which shade sample points were taken (only one facade illustrated).

Many of the trees in the study area are deciduous, and therefore cast denser shade in the summer months than in winter months. For this reason it was necessary to conduct two sets of measurements. Field measurements were done during leaf-off conditions using the January 21 solar path and during leaf-on conditions using the July 21 solar path. Additional information gathered about the individual homes included: 1) estimated square footage of walls of each building facade, 2) estimated square footage of windows of each building facade, and 3) roof color.

Measurement of Vegetative Wind Shielding to Homes

Since the sun is a point source of radiant energy, its predictable path can be used to determine which trees will directly impact a building through shade. Wind, however, does not originate from a point source and is much less predictable. Thus, determining which trees significantly and directly impact a building through shelter from wind is much more difficult.

Most studies on the use of vegetation as windbreaks have focused on rows of trees arranged to intercept prevailing winds, but trees need not be arranged in a shelterbelt formation to provide protection from winter winds. Indeed, shelterbelts are usually not possible in an urban or suburban setting due to space constraints. Tree canopies over homes provide protection by collectively slowing wind speeds and reducing infiltration of cold air into houses through gaps in caulking, weatherstripping, or insulation. The height and density of tree canopies determine the amount of slowing and turbulence created in directional winds.

Aerial photography flown for earlier phases of work in Ann Arbor was used for measuring tree canopy closure throughout the study area. Notations were made of individual trees which, in the judgment of the researchers, were positioned around homes in such a way to contribute positively to energy conservation (listed in Table 1 as Energy Conservation Canopy Closure). Canopy closure was measured by using a dot grid procedure on the aerial photo. The dot grid tally was repeated three times to provide higher accuracy. The total canopy closure and canopy closure contributing to energy conservation for the three strata are shown in Table 1.

Table 1. Tree Canopy Closure

Stratum	% Total Canopy Closure	% Energy Conservation Canopy Closure
1	15	2
2	45	14
3	66	22

To evaluate the density of vegetation on a house-by-house basis, tree canopy closure was measured on the aerial photographs using a template representing a 200 foot radius around each building. The circle formed by the 200 foot radius was subdivided into eight 45 degree wedges or octants. The borders of the octants were formed by the compass points N, NE, E, SE, S, SW, W, and NW. Percent total canopy closure and percent energy conservation canopy closure was measured for each octant using the dot grid procedure, again repeating tallies three times for each octant.

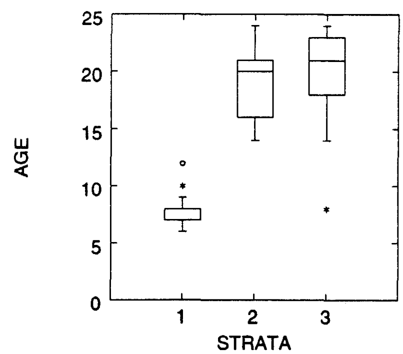
Adjacent buildings also provide wind shielding to the houses in the study area. Other buildings within a 200 foot radius circle around each building were evaluated through aerial photo interpretation. Once again the circle was divided into octants of 45 degrees, and within each octant the angle subtended by adjacent buildings was measured to the closest five degrees. The combination of canopy closure and adjacent-building shielding data derived from aerial photography gives a useful measure of wind shielding by vegetation and nearby structures.

RESULTS AND DISCUSSION

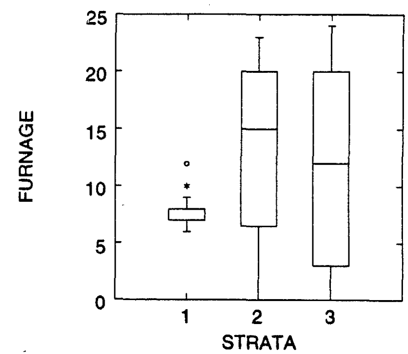
Survey Data and Vegetation Measurements

The homeowner survey data provided insights into how buildings influence energy use. Three of these characteristics: building age, furnace age, and building size, were plotted by strata with the three vegetation measurements in Figure 3a-3f.

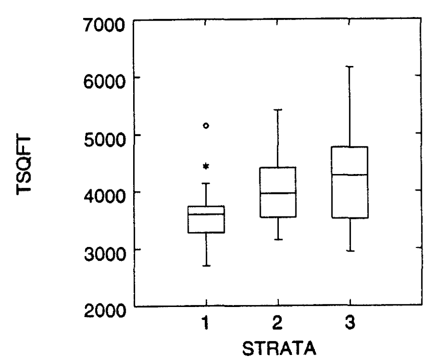
Air conditioner age was, in the majority of cases, similar to furnace age, so comments about furnaces apply to air conditioners as well. The patterns which are apparent in the plots of these variables, as well as in statistical tests, indicate that strata 2 and 3 are quite similar in terms of building age, furnace



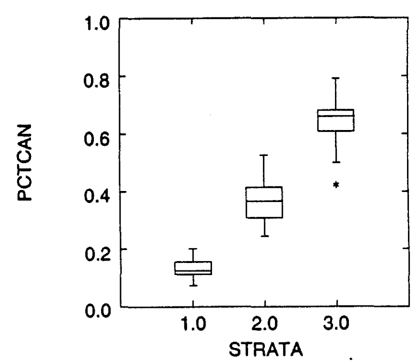
3a. Building Age



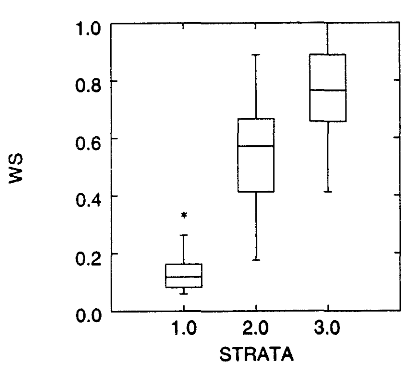
3b. Furnace Age



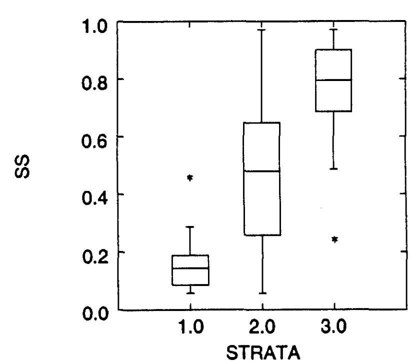
3c. Building Size



3d. Tree Canopy Cover



3e. Winter Shade



3f. Summer Shade

Figures 3a -- 3f. Building and vegetation characteristics from survey data.

age, and building size, but that stratum 1 is different from both other strata. Buildings in stratum 1 are newer and generally smaller than buildings in strata 2 or 3. Furnace ages in strata 2 and 3 range from brand new to as old as the house, indicating that some furnaces in older houses have recently been replaced while some 23- and 24-year old furnaces are still in use. All houses in the study area have gas furnaces.

Differences in building size among strata are not as dramatic as differences in building age and furnace age, but they are far easier to calculate in the analysis of energy use, requiring only that energy use be considered per square foot of living space. Unfortunately, building age and furnace age are not as readily correlated to insulation, infiltration, and furnace energy efficiency. Newer houses generally have more insulation and are less leaky than older houses, but age by itself is not a very good measure of insulation or infiltration. Likewise, furnace age has no simple relationship to furnace efficiency.

The measurements of wall area and window area for each house facade were considered both as simple square footage and also as a proportion of each facade which was window area (window area divided by wall area). Homes might be expected to have more windows on the south facade. More windows on the north facade might be expected to correlate with increased winter energy use, since the sun never shines on the north side and because most infiltration occurs around windows and the coldest winds come out of the north. However, the survey data indicate that the study area is not very homogeneous in terms of building characteristics, making it difficult to separate vegetation effects from the effects of building characteristics.

Vegetation Measurements

Tree canopy cover, measured by dot grid off of the aerial photo, strongly differentiates among the strata almost perfectly, as would be expected since the strata were determined from the same photo (see the variable PCTCAN, the proportion canopy, in Figure 3d). The two other vegetation measures, winter shade and summer shade (noted as WS and SS in Figures 3e and 3f) display a wider range of values within the strata. Further analysis is needed to ascertain how these variations relate to energy use.

The researchers viewed canopy cover (PCTCAN) as a measure of wind shielding since it measured horizontal vegetation density in sections of space (octants) around a building, while WS and SS were viewed as measures of shading since they quantified vegetation obscuring the path of the sun in the sky.

Preliminary interpretation of the results indicated that increased winter shade is moderately correlated with increased winter energy use. All three vegetation variables seemed to reflect the expectations of the researchers for any given measurement in a stable and repeatable manner, lending some confidence to the belief that they all contained useful information. In other words, the values of the measured variables made sense when observing the physical world on which they were made.

Energy Use Data

The analysis of energy use data is complicated by the fact that the researchers only have the combined end result of many factors to examine in utility company billing data. Unless all of these factors can be measured, or at least estimated, attributing fractions of total energy use to particular factors is difficult. The natural gas and electricity use data (in Btu per day per square foot) were plotted by stratum over time (Figures 4 and 5). These plots of a relationship noted in some of the building characteristics. The lower energy use in stratum 1 may be attributed to building characteristics, because the houses in stratum 1 are newer and are assumed to be tighter and better insulated.

Each plot of gas use has one peak in the winter heating season. In contrast, each plot of electricity use has two peaks, one in the summer cooling season due primarily to air conditioning and a smaller peak in the winter due to furnace fans and increased need for lighting. The winter peak in gas use is ten times larger than the summer electricity peak, confirming that Ann Arbor needs more heating energy.

Natural Gas Energy Use

Gas energy use in each individual billing period and over the heating season as a whole were not statistically significantly different for homes in strata 2 and 3. Stratum 1 has lower gas use during non-summer months. The lack of any differences among the strata in the summer is to be expected, since gas is used essentially only for cooking and water heating (in some houses) during the summer. Differences start to emerge as winter progresses which may be due mainly to the requirement for heating. Stratum 1 may have lower energy use than the strata 2 or 3 either because solar gain is more important than wind sheltering when it is cold or because the houses in stratum 1 are better insulated, tighter, and have more efficient furnaces, or for a combination of reasons.

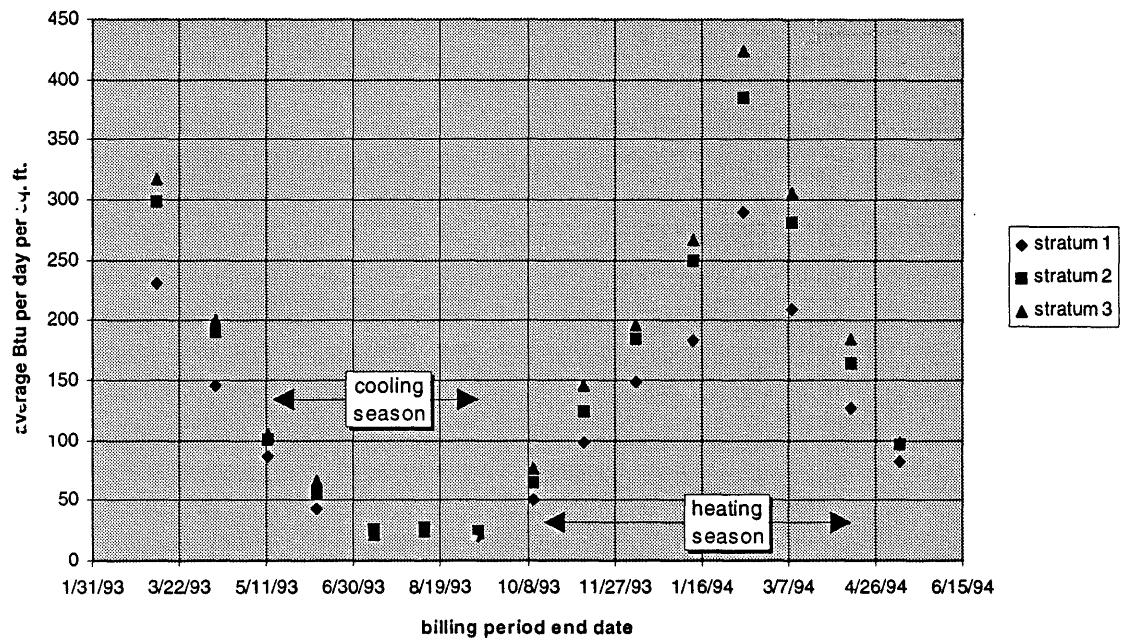


Figure 4. Gas energy use over time.

The lack of significant difference in gas energy use between strata 2 and 3 may be attributed to their similarity in the building characteristics and/or similarities in winter shading by trees. However, although gas use is not statistically significantly different between strata 2 and 3 as a whole due to the large variation in the data, stratum 3 has higher *average* gas energy use in every billing period during the heating season. Stratum 3 receives on average less solar gain, but more wind shielding than stratum 2, suggesting that a lack of solar gain may be related to higher heating requirements and that solar gain may be a stronger factor than wind shielding in determining energy use.

Electricity Energy Use

Only two billing periods exhibited statistically significant differences in electrical energy use between strata: those with end dates of 6/13/93 and 10/15/93. The large number of uses for electricity (such as, lights, television, stereo, vacuum, washing machine, and refrigerator) leading to larger variation in electricity use than in gas use counteract any significant differences among strata.

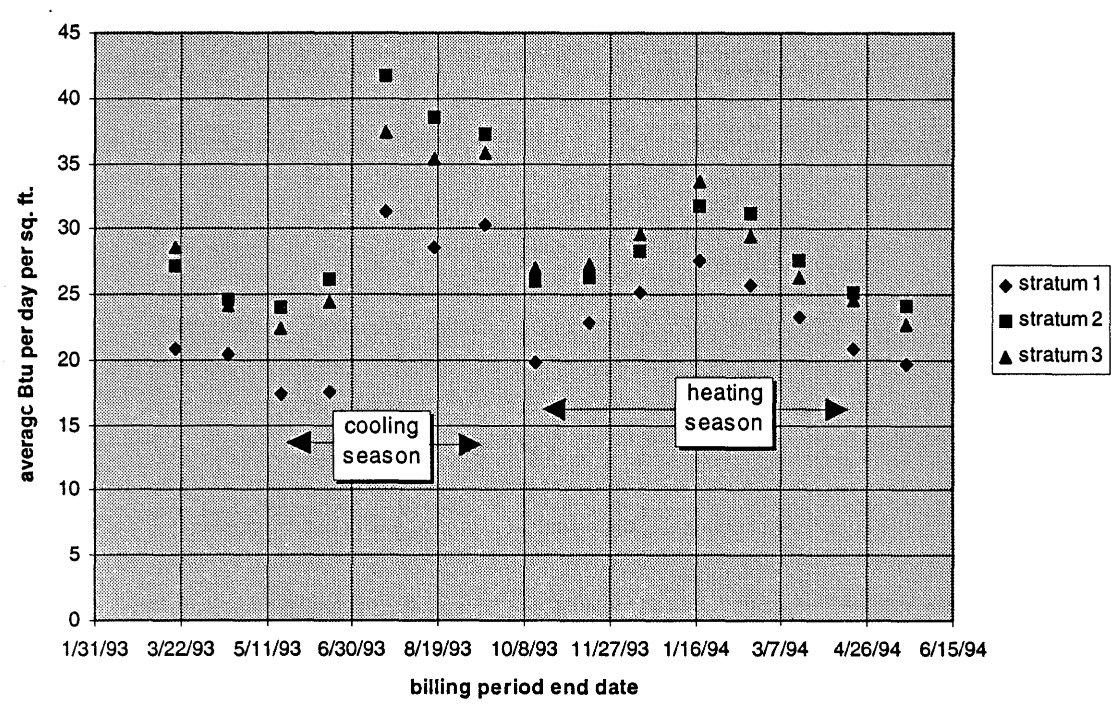


Figure 5. Electricity energy use over time.

Useful information is contained in the data even without statistically significant differences. Stratum 1 had lower average electricity use for every billing period considered (Figure 5). This may support the importance of building characteristics in determining energy use: despite much higher solar gain in stratum 1, more efficient air conditioners and insulation still resulted in lower electricity use. Strata 2 and 3 have similar building characteristics. Yet, during the cooling season, stratum 2 has higher electricity use in every billing period, less tree shade, and higher solar gain.

Anecdotal evidence, such as the amount of time air conditioners were running, how uncomfortable data takers got working in the sun, and how long snow cover stayed on the ground in winter all indicate that vegetation is a large factor in determining the microclimate around buildings, at least that portion of microclimate which is due to solar gain.

SUMMARY

Data were collected on building characteristics, energy use, vegetation, and, to a lesser extent, occupant behavior in a residential neighborhood in Ann Arbor, Michigan with three distinct levels of vegetation density. Vegetation density (tree canopy cover) is low in stratum 1 (15%), moderate in stratum 2 (45%), and high in stratum 3 (60%). Statistical and graphical analyses were performed to examine the effect of vegetation on energy used for heating and cooling in these single-family residential buildings.

Strata 2 and 3 were similar in building characteristics, and stratum 1, the area of newer homes, was different from both other strata. Strata 2 and 3 were similar in gas energy use per square foot over all time periods considered. Stratum 1 was different from the other two strata in gas energy use, except for several billing periods in the summer. No difference in electricity energy use per square foot among strata was measured, except for two minor cases. Patterns of energy use among strata were apparent, although they lacked statistical significance.

Building characteristics appeared to be a stronger factor than vegetation in determining average energy use, which was lower in stratum 1. Differences in energy use between strata 2 and 3, which were more similar in building characteristics, were thought to be more a result of differences in vegetation. Higher energy use in stratum 3 in winter was consistent with the higher amount of vegetative shade; higher electricity use in stratum 2 in

summer was consistent with the lower amount of vegetative shade.

The variation in energy use was high due to two categories: 1) building characteristics and vegetation, and 2) all other factors, including occupant behavior, considered random variation or "noise".

This study was the first step towards a field methodology to quantify the effects of vegetation on residential space conditioning energy use. The techniques described here were designed to not be intrusive and to require minimal time from the homeowners. They did not, unfortunately, provide enough information to reliably correct for some of the most influential factors. The results described here indicate that vegetation is a factor in determining energy use, but stop short of quantifying the strength of the relationship.

RECOMMENDATIONS

The researchers propose two complementary paths for future refinement of the work begun in this study. First, measured differences in microclimate around the houses could be compared to a reference condition outside of the study area. Temperature, wind direction, wind speed, and possibly relative humidity would be measured at sample points distributed throughout the study area and would be compared to conditions existing at, for example, the University of Michigan weather station. The interrelationships between vegetation, microclimate, and energy use would be investigated.

Second, more detailed building characteristic data could be collected, such as through a professionally conducted energy audit. Insulation, furnace and air conditioner efficiency could be more accurately determined and infiltration could be quantified with a blower-door test. This method is lengthy and requires cooperative homeowners. With both methods, occupant behavior would remain a source of unexplained variation. But, applying these methods to the study area would allow further work with the energy use and vegetation data already collected.

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This study was funded in part by a grant from the National Urban and Community Forest Advisory Council. A more detailed description of this study, including methods, statistical procedures and results, can be found in Lewis 1994 and focuses mainly on heating season gas use.

CHICAGO URBAN FOREST CLIMATE PROJECT

Nowak, D.J., E.G. McPherson, C.S. Grimmond, G.M. Heisler, C. Souch, R.H. Grant and R.A. Rowntree

INTRODUCTION

The research presented here combines measurement and computer modeling to generate the most extensive data gathered on a broad array of environmental benefits of urban trees.

Several interrelated studies in the Chicago region were conducted as part of the Chicago Urban Forest Climate Project (CUFCP) (McPherson *et al.* 1994). To better understand Chicago's urban forest ecosystem, it was essential to evaluate Chicago's physical structure (i.e., natural and artificial surface composition and distribution). Structural studies ranged from regionwide ecosystem analyses to investigations of individual trees and leaves. Concurrent studies investigated how the urban forest influences various ecological processes in a city. These processes ultimately affect environmental quality and human health and well-being. These structural and process-related studies were integrated to determine the effect of trees on the local environment and the costs and benefits associated with Chicago's urban forest.

This paper reviews the most significant findings to date of the CUFCP. For more detailed information, see McPherson *et al.* (1994) and other cited literature. Results are summarized by major research topics of the project: urban forest structure, air quality, atmospheric carbon dioxide, wind and air temperature, local-scale energy and water exchanges, potential savings in building energy use, and costs and benefits.

PROJECT RESULTS

Urban Forest Structure

Information on the structure of Chicago's urban forest ecosystem (such as species composition and tree leaf-surface area) provides the basis for understanding the urban forest functions that affect the city's environment and inhabitants. Approximately 4.1 million trees live in the City of Chicago, with an estimated 50.8 million trees across the Chicago region that encompasses Cook and DuPage Counties. Tree canopies cover 11 percent of the city and 19 percent of the region. Most of the trees in the region are small; 77 percent are less than 6 inches in diameter at breast height (dbh). Across the region, 49 percent of the trees are on institutional land, 25 percent on residential land, and 21 percent on vacant land. Tree density ranges from 28 trees/acre in Chicago to 70 trees/acre in DuPage county, the least urbanized area of the region.

Relatively short-lived pioneer species contribute significantly to the Chicago-area urban forest and are most prevalent on lands with minimal or naturalistic management (such as forest-stand conditions). These trees may constitute an even more important component of the urban forest structure in the future due to their dominance in smaller diameter classes. The most common trees in the region are buckthorn (*Rhamnus* spp.), green and white ash (*Fraxinus pennsylvanica*; *F. americana*), *Prunus* spp., boxelder (*Acer negundo*), and American elm (*Ulmus americana*), which account for 43 percent of the total tree population.

Tree leaf-surface area (the plant surface where atmospheric gases are actively exchanged) was assessed to determine the relative impact of trees on the environment (Nowak 1995). Tree species with the greatest leaf-surface area in the region are silver maple (*Acer saccharinum*), green and white ash, white oak (*Quercus alba*), American elm and boxelder, which account for 40 percent of the total leaf-surface area. These species likely have the greatest overall impact on the surrounding environment.

Street trees account for 10 percent of the city's trees and 24 percent of the total city' leaf-surface area. Street trees are less significant in more suburban or rural areas, constituting 1 of every 37 trees in suburban Cook County and 1 of every 77 trees in DuPage County. The most common ground surfaces in the Chicago region are maintained grass, tar, herbaceous cover (e.g., crops, flower beds), and buildings.

These structural data help in understanding Chicago's urban forest ecosystem, identifying and clarifying various management issues (e.g., invasion of exotic tree species), and developing estimates of various forest functions (e.g., air quality improvement) (Nowak, 1994).

Air Quality

Air pollution is a multibillion dollar problem that affects most major U.S. cities. A significant health concern, it can cause coughing, headaches, lung, throat, and eye irritation, respiratory and heart disease, and cancer. Air pollution damages vegetation and various anthropogenic materials, and reduces visibility. Trees remove pollution by intercepting particles on the plant surface and absorbing gaseous pollutants, primarily through leaf stomates.

In 1991, trees in Chicago removed an estimated 17 tons of carbon monoxide (CO), 93 tons of sulfur dioxide (SO_2), 98 tons of nitrogen dioxide (NO_2), 210 tons of ozone (O_3), and 234 tons of particles (Figure 1). Across the region, trees removed an estimated 6,145 tons of pollution. During the in-leaf season, regional pollution removal by trees averaged 1.3 tons/day of CO, 4.0 tons/day of SO_2, 4.6 tons/day of NO_2, 9.8 tons/day of particles, and 11.9 tons/day of O_3. The pollution removal value in 1991 was estimated at $1 million for trees in the city and $9.2 million for trees across the region.

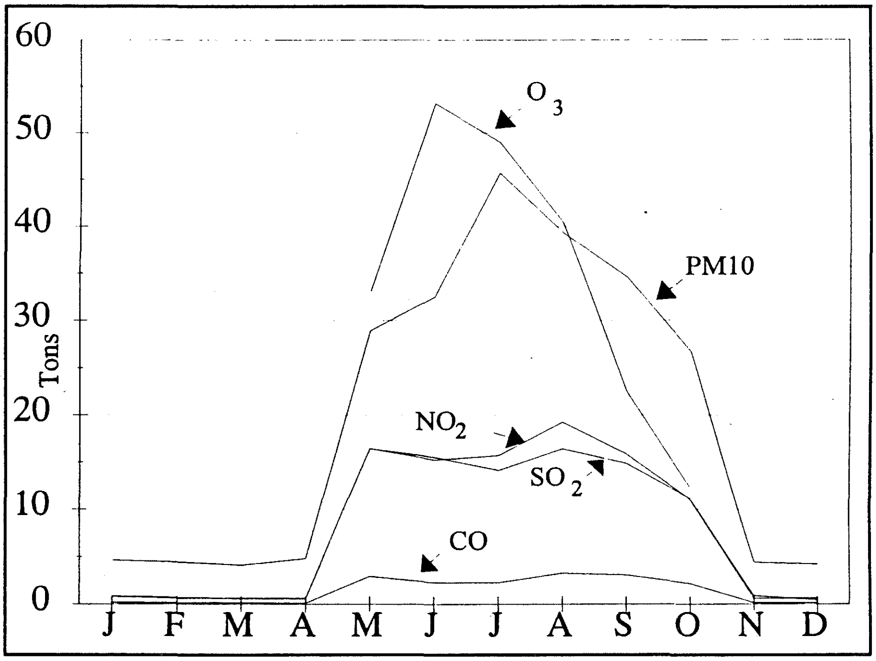

Figure 1. Monthly estimates of pollution removal by trees in Chicago in 1991. PM10 (particulate matter less than 10 microns) estimates assume 50-percent resuspension of particles.

Average hourly improvement (in-leaf season) in air quality from all trees in the Chicago area ranged from 0.002 percent for

Average hourly improvement (in-leaf season) in air quality from all trees in the Chicago area ranged from 0.002 percent for CO to 0.4 percent for particles. The estimated maximum hourly improvement was 1.3 percent for SO_2, though localized, short-term improvements in air quality can be 5 to 10 percent or greater in areas with relatively high tree cover. In 1991, large (> 30 inches dbh), healthy trees removed approximately 3.1 pounds of pollution, approximately 70 times more than small trees (< 3 inches dbh).

Atmospheric Carbon Dioxide

Increasing levels of atmospheric carbon dioxide (CO_2) and other "greenhouse" gases are thought by many to be leading to increased atmospheric temperatures through the trapping of certain wavelengths of heat in the atmosphere. In urban areas, trees offer double benefits in reducing atmospheric CO_2. First, they directly sequester and store carbon. Second, when properly located, urban trees reduce the use of energy in buildings, which in turn reduces CO_2 emissions from power plants. Trees store an estimated 942,000 tons of carbon in Chicago, and approximately 6.1 million tons throughout the Chicago area. This total area amount, which took years to store, is equivalent to the amount of carbon emitted from the residential sector in the Chicago area during a 5-month period.

Carbon storage by shrubs is approximately 4 percent of the amount stored by trees. Total carbon storage and annual sequestration are greatest on residential lands, institutional lands dominated by vegetation (e.g., parks, forest preserves), and vacant lands. Estimated net annual carbon sequestration (carbon stored via growth minus carbon lost through mortality) in the Chicago area is 155,000 tons -- the amount of carbon emitted from transportation use in the Chicago area in 1 week. Estimated carbon storage by urban forests nationally is between 440 and 990 million tons.

Carbon storage by individual trees averages about 3.5 tons for trees more than 30 inches dbh; approximately 1,000 times more carbon than stored in trees less than 3 inches dbh. Annual carbon sequestration is approximately 200 pounds for healthy trees more than 30 inches dbh, 90 times greater than healthy trees less than 3 inches dbh. The amount of carbon sequestered annually by one tree less than 3 inches dbh equals the amount emitted by one car driven 10 miles. Throughout the Chicago area, estimated carbon emissions avoided annually due to energy conservation from existing trees is approximately 12,600 tons.

Wind and Air Temperatures

By transpiring water, blocking winds, shading surfaces, and modifying the storage and exchanges of heat among urban surfaces, trees affect local climate and consequently energy use in buildings, human thermal comfort, and air quality. Researchers are developing models for estimating the effect of trees on microclimate in residential neighborhoods. From July 1992 to June 1993, windspeed, air temperature, and humidity were measured at 39 sites in and near residential neighborhoods in Chicago with specially designed equipment (Grant and Heisler, 1994). Equations to predict the influence of trees on local climate are being developed by statistically analyzing the relationships among climatic variables and urban morphology (e.g., tree and building attributes).

Preliminary data analyses for a 1-week period in summer indicate that residential buildings and trees reduced windspeeds by 46 to 85 percent (relative to an open field site at O'Hare International Airport) depending on the specific neighborhood morphology. These reductions were significantly related to tree and building configurations determined by photographic methods. Residential air temperatures generally were warmer than at the open field site due to the predominance of building surfaces. Continuing work is quantifying the specific effect of urban trees on local windspeed, air temperature, and humidity.

Local-Scale Energy and Water Exchanges

The replacement of natural surfaces (e.g., trees, grass) with artificial surfaces (e.g., buildings, roads) alters the thermal and moisture properties of the area, thereby modifying the local atmosphere and generating an "urban climate" that is commonly characterized by increased air temperatures and poorer air quality. Year-long climatic measurements across the northside of Chicago and intensive measurements taken during July 1992, of a smaller, predominantly residential area were conducted to quantify how urban morphology affects local energy and water exchanges. Observations consisted of direct measurements of sensible heat flux (energy for heating the air) and latent heat flux (energy for evapotranspiration), and net total radiation (net available energy from solar and terrestrial radiation). Researchers are combining these measurements with a detailed characterization of urban surface materials and morphology (Grimmond and Souch, 1994) to gain a general understanding of energy exchanges at the local scale. Calculation of the Bowen ratio (sensible heat flux/latent heat flux) for a period during July 1992, indicates that more energy was being used to dry surfaces (latent heat flux) than to warm the air (sensible heat flux), largely because of frequent rainfall during that month. Summertime measurements in residential areas of Tucson, Arizona, and Sacramento and Los Angeles, California, reveal that more energy was being used to warm the air in these areas than to dry surfaces (Grimmond and Oke, 1995). Of the net available energy during the daytime in Chicago, 32 percent heated the air, 38 percent evaporated water, and 30 percent heated urban surfaces. Work is in progress to relate the latent and sensible heat fluxes to tree cover. Also, numerical models are being developed to predict the effect of various tree-planting scenarios on local-scale energy and water exchanges.

Potential Building Energy Savings

Trees reduce building energy use by lowering summertime temperatures, shading buildings during the summer, and blocking winter winds. But they also increase energy use by shading buildings during the winter and either increase or decrease energy use by blocking summertime breezes. Computer simulations of microclimates and building energy performance were used to investigate the potential of shade trees to reduce residential heating and cooling energy use in Chicago (McPherson, 1994).

Increasing residential tree cover by 10 percent (corresponding to about three trees per building located in optimal energy-conserving locations) could reduce total heating and cooling energy use by 5 to 10 percent ($50 to $90 per building). On a per-tree basis, annual heating energy can be reduced by about 1.3 percent ($10, 2 MBtu), cooling energy by about 7 percent ($15, 125 kWh), and peak cooling demand by about 6 percent (0.3 kW). Benefit-cost ratios of 1.35 for trees planted around two-story brick buildings and 1.96 for trees near energy-efficient, two-story wood-frame buildings indicate that a utility-sponsored shade tree program could be cost effective for both existing and new construction in Chicago.

Street trees are a major source of building shade within Chicago. Shade from a large street tree located to the west of a typical brick residence can reduce annual air conditioning energy use by 2 to 7 percent ($17 to $25, 138 to 205 kWh) and peak cooling demand by 2 to 6 percent (0.16 to 0.6 kW). Street trees that shade the east side of buildings can produce similar cooling savings, have a negligible effect on peak cooling demand, and can slightly increase heating costs. Shade from large street trees to the south increases heating costs more than they decrease cooling costs. Proper tree selection and placement can minimize the negative energy attributes of trees.

Costs and Benefits

Dwindling budgets for tree planting and care in many cities are creating new challenges for urban forestry. Community officials are asking if trees are worth the price to plant and maintain them over the long term. To address this issue, a benefit-cost analysis was used to estimate the net present value, benefit-cost ratio, and discounted payback periods (i.e., the number of years a tree must survive to yield net positive benefits) of proposed tree plantings in Chicago. For this analysis, 95,000 green ash were assumed to be planted along streets (50,000 trees), in yards (25,000), parks (12,500), along highways (5,000), and at public housing sites (2,500). Estimated annual costs and benefits associated with the planting and maintenance of these trees over a 30-year period were based on a 7-percent discount rate.

Projected present benefits were $59 million with a present cost of $21 million, yielding a net present value of $38 million, or $402 per tree. Expenditures for planting alone accounted for 88 percent of projected costs except at public housing sites where volunteer plantings were assumed. The largest benefits were attributed to "other" benefits (all benefits exclusive of energy, air quality, and hydrologic benefits) (60 percent) and energy savings (37 percent).

Projected benefit-cost ratios were largest for trees planted in residential yards and public housing sites (3.5), and least for parks (2.1) and highways (2.3). Discounted payback periods ranged from 9 to 15 years. These findings indicate that despite the expense of planting and maintaining trees in Chicago, the benefits that healthy trees produce can exceed their costs over time.

CONCLUSION

Although many attributes of Chicago's urban forest ecosystem have been analyzed (McPherson et al., 1994), research continues as part of the CUFCP. Topics still being analyzed include: modeling the effect of urban trees on ozone concentrations; emissions of volatile organic compounds by urban vegetation; measuring and modeling the effect of urban trees on microclimate; modeling the effect of urban trees on local-scale hydroclimate; landscape carbon budgets and planning guidelines; and the use of airborne videography to describe urban forest cover.

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COOL COMMUNITIES: A NATIONAL EFFORT TO SAVE ENERGY AND REDUCE HEAT ISLANDS

Gary Moll, American Forests

INTRODUCTION

This national program is in the forefront in promoting research-based local tree planting to achieve energy conservation benefits.

Cool Communities is a national program designed to lower summer heat island temperatures, reduce energy use, and lower carbon emissions. This public/private partnership was initiated in 1991 by AMERICAN FORESTS and the Environmental Protection Agency (EPA). Many other national and local partners were quickly added, including several public utility companies in participating cities. In 1993, after about 18 months of successful action, Cool Communities was incorporated into the Clinton Climate Action Plan, and agency leadership moved from the EPA to the Department of Energy. Now, Cool Communities is putting in place networks to implement programs and measure the value of trees for cooling urban heat islands, saving energy and lowering the CO_2 pumped into the air.

BACKGROUND

AMERICAN FORESTS, established in 1875, is the oldest national citizen's conservation organization. AMERICAN FORESTS created an urban forestry program in 1981 to address conservation concerns in the places where people live, and then, conducted three national surveys of urban forests that helped guide changes in public policy. Recent AMERICAN FORESTS efforts, such as the creation of Global ReLeaf, have provided the operational and scientific underpinning for Cool Communities.

When the EPA asked AMERICAN FORESTS to help them create a program to address the urban heat island problem, AMERICAN FORESTS had already participated in several scientific workshops addressing the topic of urban heat islands. The results were published by the EPA in a book called *Cooling Our Communities*. Some findings were:

- Cities are five to nine degrees hotter than the surrounding countryside and can be described as heat islands.
- Urban heat islands cause people to use billions of dollars in energy for cooling annually.
- Air quality is directly related to the heat island effect. The hotter the temperature, the more air pollution.
- Heat islands can be reduced by increasing tree cover and surface albedo (more light-colored surfaces).
- The least expensive, most effective way to increase tree cover and surface color is to mobilize community action.

With these facts in mind, the EPA and AMERICAN FORESTS worked out a strategy to build this national program called Cool Communities. Federal agencies and national organizations were asked to participate in a national advisory council to help coordinate collective action and build a national partnership. Seven cities were selected to become model communities where theory would be tested and action would take place. Since AMERICAN FORESTS believes in building programs from the ground up rather than from the top down, Local Advisory Committees were established in each community to direct local action.

THE COOL COMMUNITIES APPROACH

The Cool Communities program is built on a solid science foundation. However, its main feature is community action to organize government, business, and citizens to lower heat island temperatures and reduce energy consumption. In this effort, the local utility company is perhaps the most important local partner, because it produces the energy, has a responsibility to help its consumers conserve energy, and is in the unique position to measure energy consumption as one gauge of success.

Already, in the first three years of the program, community participation is high. Local business and industry, led by the utility groups, have provided a 7 to 1 dollar match for the program. In other words, for each dollar spent to organize the program nationally, $7 was spent to create action at the local level. Most of this money came from local partners.

Program Goals

The goal of the Cool Communities program is to reduce energy consumption, especially at peak use hours, and to reduce greenhouse gas emissions from projected year 2000 levels by 4.4 million metric tons (MMTs) of carbon.

To achieve these goals, the Cool Communities program aims to accomplish the following by the year 2000:

- The successful implementation of a Cool Communities program in 250 local communities and 100 Federal facilities.
- An increase in community-wide tree cover, the number of strategically planted trees, and the number of building- and paving-surface albedos changed through public/private partnerships.

Utility Involvement

The Cool Communities program gives public utilities a way to do well by doing good. Data from several research stations around the country show that judicious use of trees and light-colored surfaces can pay dividends to the people that produce power, and the people that use the power. Strong support from the local utility company is essential to this program's development. Already, several utility companies are participating.

In 1994, local efforts to increase tree cover and monitor and measure temperature and energy use were taken on by utility companies in five cities -- Tucson, Arizona; Miami, Florida; Austin, Texas; Frederick, Maryland; and Atlanta, Georgia. In these cities, the utility companies donated resources to measure energy use in various kinds of ecological settings. They are helping AMERICAN FORESTS collect energy use information and relate it to tree density and location and the percent of light-colored surfaces.

The Benefits of Trees

Few actions cost less money and bring more benefits to the environment than having trees planted in the right place. For example, USDA Forest Service researcher Gordon Heisler estimated that $1.2 billion in energy costs would be saved if trees already growing in communities across the country could be relocated optimally. Planting new ones in the right spots will save even more.

Throughout the United States, a broad range of benefits from urban trees are being demonstrated. Research conducted at the Lawrence Berkeley Laboratory, and by Greg McPherson at the USDA Forest Service in Davis, showed that three trees located in the right locations will save over 10% and as much as 50% on cooling bills in some locations.

Tree cover is currently a little less than 30% in eastern cities and about 17% in the drier parts of the west. But, heat island temperatures could be lowered by several degrees if the tree canopy can be increased by 10 to 20%. Lowering heat island temperatures reduces air pollution. In the summer, city heat islands act like a Bunsen burner warming chemicals in the air so they mix and cause smog. Increased tree cover slows stormwater flow, reduces soil erosion and non-point pollution, and generally improves public health.

Several studies by Roger Ulrich from Texas A&M and the Kaplans at the University of Michigan show the impact of trees on human health. Ulrich's data show hospital patient recovery rates improve when they have a view of trees.

Measuring Positive Community Action

Everyone wants proof that these simple energy-saving, heat island reduction techniques will work in their communities. So AMERICAN FORESTS designed a system to measure the effects of positive community action. This Urban Ecological Analysis methodology using Geographic Information System (GIS) technology allows AMERICAN FORESTS to work with any city in the country and to provide the data needed to evaluate the benefits of local actions. A national standard is being created to be used by urban decision makers nationwide.

In the city of Frederick, Maryland, the Cool Communities program is developing a database with GIS to quantify information on the benefits of trees. First, the whole area was stratified by ecological classes. Then, low-level aerial photography of neighborhood demonstration sites was used to quantify each type of land cover and identify each existing tree. This information was ground-truthed, completing the tree-by-tree information in the database. For example, one site analyzed has a 23% tree canopy and around 40% impervious surfaces. These aerial photos effectively show planning commissioners and residents about the environmental effects and stormwater management implications of canopy cover and impervious surfaces in a neighborhood they know.

Then energy savings from the placement of trees was determined. Dr. Greg McPherson's data were applied on how much shade and energy savings are produced by trees at various distances and sizes. In a typical block in Frederick, Maryland, direct summer energy savings from trees is $1330 and from light-colored roofs is $60. Thus, between the light surfaces and the trees, annual savings were already close to $2000.

To determine the impact of tree growth over time, comparisons were made between two similar communities: one that did have a canopy cover and one that did not. Measurements were done in both to see how temperature effects changed. In addition, developers and builders were involved in tree planting. In Frederick one developer had planted trees, but put them in the wrong place. As those poorly located trees matured, they would only provide $600 in direct energy savings. Yet, if the trees were located strategically, they would be saving somewhere in the range of $16,000. This demonstrates big opportunities without spending any more money.

Techniques for measuring the ecological effects of trees are being adapted to each community's resources. For example, in Frederick a system was developed for residents to record temperatures everyday. In contrast, at the Davis Monthan Air Force Base in Arizona, energy use of identical military housing units is being measured. The University of Arizona has three weather stations digitally measuring air temperature minute-by-minute as well as windspeed. Both the direct and indirect effects of trees are being measured for a 20 acre site.

CONCLUSION

To paraphrase David Freeman from the Sacramento Utility District, "I did not need an expert to tell me a tree was going to save energy, all I needed to do was walk out into my yard". But, communities need to make tough business decisions based on facts. Clearly, working with the environment and promoting the use of trees for energy conservation and Demand Side Management is good business.

Charlie Bayless, CEO of Tucson Electric Power (TEP), said, "It is a lot cheaper to plant trees than it is to build a power plant". Charlie Bayless makes it sound very simple, but he can discuss cost and benefit information with investors to show that trees not only save energy during peak load periods, but also help TEP use less water, a precious commodity in Tucson. TEP's participation with this model Cool Community makes dollars and sense to them and the residents of Tucson.

The Cool Communities program is a good idea that improves the environment and provides a good investment for utility companies. Here are some benefits to the utility company:

- good public relations,
- promotion of energy efficiency,
- cost-effective way to conserve energy,
- scientific credibility, and
- increased employee pride.

Everyone is a piece of the environment and can create change. Changes are most efficient around the home, yet actions are more effective at changing the environment when they are done collectively.

Cool Communities deploys collective national, state, and local actions with AMERICAN FORESTS as a partnership broker. Cool Communities also identifies ways to get collective action through good science, monetary values, and development of techniques for decision makers to use at the community level. Thereby, Cool Communities is win-win for utility companies, communities and the environment.

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In his 12 years at AMERICAN FORESTS, Mr. Moll has developed their urban forestry program and publications and has chaired five national urban forestry conferences. Previously, he had 10 years urban forestry experience including positions as a utility company forester and an urban forestry coordinator with a state forestry agency. Mr. Moll holds a degree in Forestry (Michigan State University) and is author of *Shading Our Cities* and *Growing Greener Cities.*

WINDBREAKS: WORKING TREES TO MODIFY COMMUNITY MICROCLIMATES

Kris M. Irwin, USDA Forest Service, National Agroforestry Center

INTRODUCTION

This paper expands the Power of Trees by addressing energy use and its relation to vegetation in the broadest sense from energy used for heating and cooling buildings, to vehicular use, to human energy. It also recognizes the value of conserving built and natural environments and efficiently increasing their function through the use of working trees.

Planting tree windbreaks has a long history in the United States. In the 1860's, homesteaders planted trees around their homes and property boundaries to slow the force of the ever-present wind, provide shade from the sun, and break up the monotony of the treeless plains. Congress viewed tree planting as a vital component of settlement. Support for planting on the Great Plains was so strong the Timber Culture Act of 1873 was passed to encourage tree planting on all new homestead lands.

In 1902, the Nebraska National Forest was established as the first large-scale demonstration to promote tree planting in the Great Plains. Many tree species were planted and tested for use as windbreaks. The Shelterbelt Project (1935-1942), commonly referred to as the Prairie States Forestry Project, was the largest planting effort to date by the U.S. Forest Service, and was designed to provide direct assistance to farmers and ranchers in planning and establishing windbreak systems. This effort extended from North Dakota to northern Texas.

Over the last century, much has been learned about windbreaks - how they function, how to plant them, and how they can improve environmental conditions for people, wildlife, and livestock. Most often, windbreaks are planted around individual homes and work areas to protect and enhance the life of humans and animals. However, if properly designed and located, windbreaks can be planted to protect entire neighborhoods and even communities. Windbreaks are one of several agroforestry technologies putting trees to work to save energy and conserve the environment.

This paper provides information about windbreaks and other agroforestry technologies and how trees work to conserve energy and protect community environments. Subjects covered include: 1) putting trees to work; 2) effects on microclimate; 3) design considerations; 4) planting requirements; 5) maintenance; and 6) other agroforestry technologies that conserve energy and improve the environment.

PUTTING TREES TO WORK

Reduce Energy Use

One of the most commonly recognized jobs of a windbreak is its ability to reduce energy consumption. About 17 percent of the total energy used in the United States is consumed by the residential sector, of which 11 percent is used to condition indoor environments. Heating is the largest consumer at 9 percent while the remaining 2 percent is used for cooling (DeWalle and Heisler 1988).

About one-third of the winter heat loss from a home occurs through the process of air exchange. Pressure differences cause air exchange. These differences are created by indoor and outdoor temperature gradients and the force of wind on the home's exterior surfaces (Figure 1). Wind affects the air exchange rate and therefore the heat-transfer rate. Anytime the inside temperature of a building is higher than the outside, heat loss will occur. Adding the effect of cold winter winds to the equation increases the rate of air exchange and heat loss. In the northeastern and north central United States, reducing wind velocity with a windbreak can result in heat energy savings of 10 to 25 percent (DeWalle and Heisler 1988).

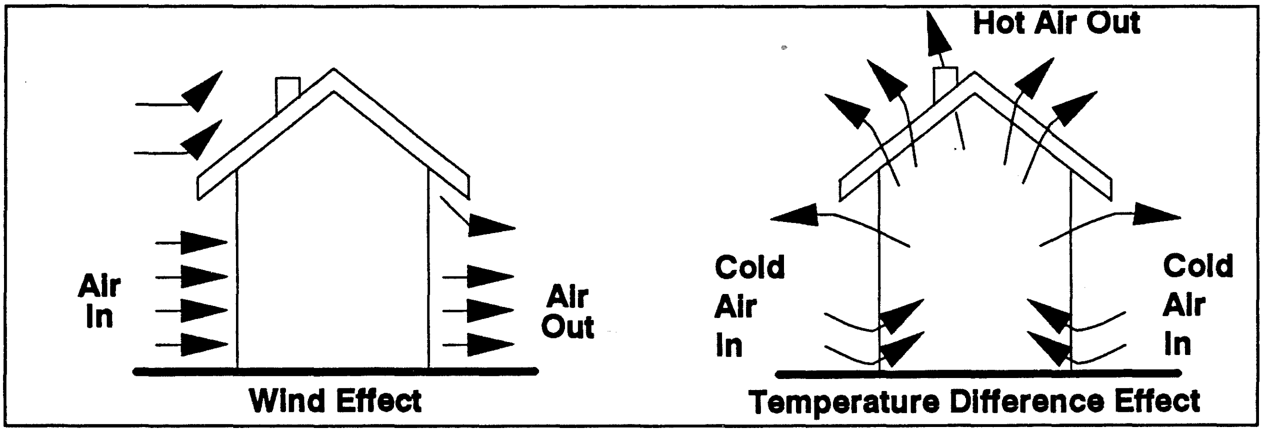

Figure 1. The force of wind against the exterior surface of a home and inside and outside temperature gradients affect the air exchange rate of a home.

Although not often discussed, windbreaks along roadways can also reduce motor vehicle fuel consumption and improve the driving conditions of all vehicle types, from small compacts to tractor-trailer rigs. Planted parallel to a road, a properly designed windbreak can eliminate crosswinds, reduce driver fatigue, improve safety, and improve fuel efficiency. Tree windbreaks planted adjacent to any road must be located an appropriate distance away from the road to allow for snow drifting. Prevailing direction of winter winds and average snow accumulation data will need to be factored into the design strategy.

Improve Work Area Environment

Anytime a person is working outside, work efficiency is increased when environmental conditions are within tolerable limits. Cold temperatures and winter winds generate negative windchill factors and unproductive work environments.

This is a job for a windbreak. For example, a multi-row (60-80% density) windbreak is planted around a residence and is 25 feet tall; the wind is blowing at 20 mph; and the air temperature is 20 degrees Fahrenheit. In the open field, the windchill factor makes it feel like minus 9 degrees. But, within 125 feet behind the windbreak (the zone of protection), the wind speed is decreased to 5 mph, hence the windchill factor is decreased, and the apparent temperature is increased to 16 degrees. The time a person can spend working safely and comfortably outside is extended when they are within the protected area.

Control Drifting Snow

Windbreaks reduce wind velocity and drifting snow. Drifting snow can create a burden around homes, work areas, and roads because snow removal takes time and energy to accomplish. Also, if snow has to be "pushed", space is needed to pile it, otherwise hauling is the expensive alternative. During the spring melt, runoff from the snow piles can create extended wet areas causing more problems.

Windbreaks capture snow within the planting and cause drifts both in front and behind, thereby keeping it away from the protected area. If snow control is the primary function of a windbreak planting, the windbreak must be a sufficient distance from the protected area. A rule of thumb is to keep the leeward row 200 feet from the area to be protected. More information about snowfences will be presented later in this paper.

Control Noise and Dust

Residents living next to agricultural fields, along busy traffic ways, or next to gravel roads must contend with noise and dust. Properly designed and located, windbreak plantings can reduce noise levels and filter dust.

Noise control is best achieved when solid barriers (earth berms, brick walls, etc.) are combined with trees and shrubs. Sound levels can be reduced by 10 and 15 decibels - less than half as loud (Cook and Van Haverbeke 1974). Strategically designed tree plantings can buffer sounds to tolerable levels and create a more pleasant atmosphere in which to work and live.

Filtering dust from gravel roads, agricultural fields, or wind is generally a secondary purpose of a windbreak. Density and tree canopy architecture determine the effectiveness of a windbreak to capture dust particles. Reasons to reduce dust in the air include increased driving safety and health conditions. Reduced visibility from blowing dust is a contributor to highway accidents in some areas of the Great Plains. People with allergies and upper respiratory problems need clean air to breathe. Windbreaks, with their inherent ability to filter the air, do much to reduce the air quality problem.

Reduce Wind Damage

Wind and windblown soil cause significant damage to buildings and property. Strong unabated winds tear roofs from buildings and break out windows. Windblown soil particles are responsible for decreasing the normal life expectancy of paint on homes and vehicles. In regions with expansive areas of bare soil and strong winds, soil particles are picked up and carried by the wind. The resulting damage is similar to that of a sandblaster. Planting windbreaks around building sites provides significant protection from damaging winds and wind blown soil.

Secondary Benefits

The primary purpose of planting a windbreak will dominate decisions regarding species, arrangement, and spacing. In addition to satisfying the primary purpose, windbreaks also provide secondary benefits such as wildlife habitat, increased land value, and social benefits.

Planting tree windbreaks will increase biodiversity in the landscape, which will provide habitat for various forms of wildlife. The species of trees and shrubs, their arrangement and spacing (density), their location in relation to other landforms, and their proximity to available sources of food, water, and nesting habitat play a role in attracting different kinds of wildlife.

Trees provide a service, and the sales value of property reflect these benefits. Builders have reported homes situated on wooded lots sell for an estimated average of 7 percent more than comparable houses on unwooded lots (Selia and Anderson 1982).

Social benefits of tree plantings should not be overlooked. Landscapes planted with trees can reduce stress, decrease patient recovery time, enhance psychological health, increase human productivity, and create a greater sense of community pride.

EFFECTS ON MICROCLIMATE

Wind Velocity

Windbreak height and density are responsible for reducing wind velocity. Windbreak height determines the distance at which downwind velocity reduction occurs and is directly proportional to the height of the tallest tree row in the windbreak. This distance is expressed in multiples of the tree height (H). Windbreak density is the ratio of the solid portion of the planting to the total area of the planting. Windbreak density determines the amount of air allowed to pass through and thus the percentage wind velocity is reduced. Table 1 compares various windbreak densities and their effectiveness at reducing wind speed measured 10H downwind for an open wind velocity of 20 mph.

For a given windbreak, measurable wind velocity reduction extends 2 to 5H upwind and up to 30H downwind from the windbreak (Brandle and Finch 1991). For example, a windbreak that is 30 feet tall (H=30), the wind velocity will be reduced 60 to 150 feet (2 to 5H) upwind and up to 900 feet (30H) downwind.

Table 1. The Effect of Density on Wind Reduction.

Windbreak Density (%)	Wind Velocity (mph @ 10H leeward)	Wind Reduction (% of open wind velocity)
25 - 35	13	65
40 - 60	10	50
60 - 80	7	35
100	14	70

Air Temperature and Humidity

When compared to open area conditions, air temperature is usually several degrees warmer within 10H downwind and 2 to 3H upwind of a windbreak. As air is pushed up over the windbreak, a "protected zone" is formed where turbulence is lessened and eddy size is reduced, thus impeding the cooling effect of wind. Beyond the protected zone, a "wake region" forms, turbulence and eddy size increases, and a cooling effect results.

On average, the relative humidity in the protected zone of a windbreak is from 2 to 4 percent higher compared to open areas. Therefore, the combination of slightly increased temperatures and relative humidity within the protected zone have a net effect of improved growth for gardens, flower beds, and lawns.

Soil Temperature and Moisture

Soils will be slightly warmer in the protected zone than the unprotected area for many of the same reasons that air temperature and humidity are increased. Windbreak orientation is a significant factor with regard to soil temperature and moisture. For example, the soil on the south side of an east-west oriented windbreak will be warmer than on the north side, and drier because snow melt on the north side is slower. Therefore, careful consideration must be given to the land use objectives for both sides of the windbreak during the design phase.

DESIGN CONSIDERATIONS

When a windbreak is needed, what is the process? First, contact the local resource professional - state forestry agency, Natural Resource Conservation Service (formerly the Soil

Conservation Service), community forester, conservation district technician, soil and water conservation district, resource conservation and development office, or private forestry consultant. These professionals provide the technical resources necessary to accomplish the job from start to finish. They guide the landowner through the steps of identifying the primary purpose of the windbreak, after which they can recommend appropriate tree/shrub species, provide various design options to fulfill the planting objective, coordinate the planting operation, and monitor the maintenance of the planting after it is established.

Purpose of Design

Planting a windbreak is a long-term investment of both time and money. The benefits derived from such a planting are long-term as well. Therefore, special attention must be given to the primary purpose of the windbreak. During the initial design phase of the project the landowner must clearly communicate the objective for planting the windbreak to the resource professional. By doing so, the project design options generated by the professional will meet the objectives of the landowner.

Windbreaks located around homes, buildings, communities, and along emergency routes are typically designed to reduce wind velocity or protect from drifting snow. Under certain landscape conditions, designing for both wind and snow control is possible. However, if snow control is the primary purpose then it is possible that wind protection may be sacrificed to some degree.

The primary purpose will determine the species selected to be planted, their arrangement, and spacing. Intentional or not, other objectives, such as wildlife habitat, screening for privacy, noise control, landscape enhancement (increased property value), and changes in microclimate, will be realized by planting tree windbreaks.

Species Selection

Species selection is based on the primary purpose of the planting, soil type, annual precipitation, growth and fruiting habit, genetic quality, crown form, and density. A mistake at this stage can be costly. Beyond species characteristics, other factors need to be considered when selecting a source and purchasing planting stock.

All planting stock should be purchased from a reputable source such as a state tree nursery or recommended private nursery. Production nurseries will have competitive prices, quality stock, and numerous varieties of species suitable for various site conditions.

The suitability of planting stock is improved if it is grown from seed collected locally. However, if seedlings grown from local sources are not available, and they come from somewhere else, inquire about their compatibility with local growing conditions.

If available, seedlings known to be resistant to prevalent insects and diseases should be planted. Seedlings resistant to insect and disease attack may be more expensive, but planting genetically improved stock will help protect the investment from failure.

Location, Arrangement, and Spacing

The information presented below is not generally applicable to small lots (less than ¼ acre) because plantings on small areas can directly affect adjacent lots. Plantings intended to protect housing developments must be suitably located to provide adequate protection for many homes, thus eliminating the need for individual plantings and potential problems.

For winter protection in the Midwest, windbreaks should be planted on the north and west sides of the area to be protected, and always perpendicular to the prevailing wind direction. The primary area in need of protection should be within 2 to 5H of the tallest tree (Figure 2).

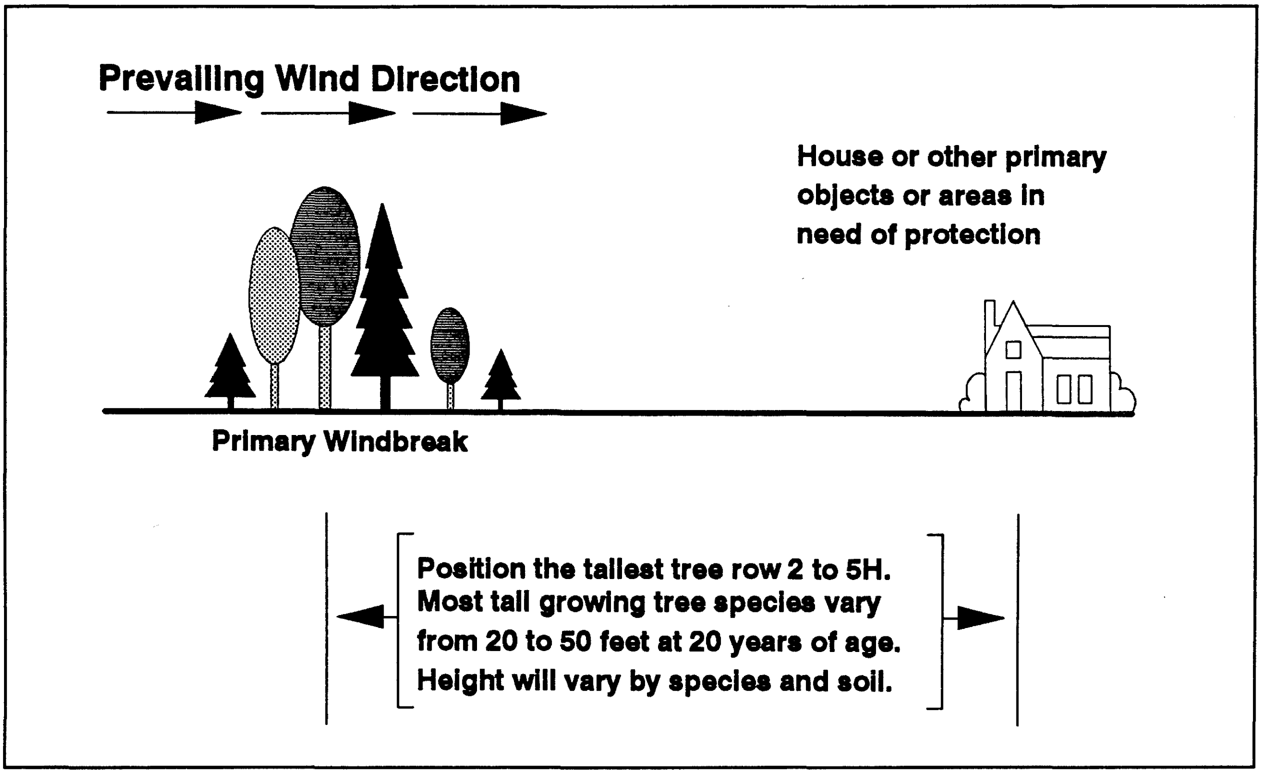

Figure 2. Illustrating correct location of windbreak relative to area in need of protection.

Access roads should be located at the ends of the windbreak. Openings allow wind to funnel through the gap. If a road must pass through a windbreak, it should be located at an angle, and opposite, to prevailing wind direction. Windbreaks for the purpose of snow control should not have any roads passing through because deep snowdrifts will accumulate within the opening. To minimize snowdrift problems, lanes or roads should be located a minimum of 100 feet past the ends of the windbreak. Property lines, subsurface drains, power and telephone transmission lines, and septic fields must be located and identified because they have a direct impact on the placement of windbreak plantings, and should be avoided if possible.

Slower-growing and shorter species must be planted in the outer rows to ensure adequate light is received and they are not shaded by the taller, faster growing species. The width of a windbreak can vary from a single row to eight or more. For the primary purpose of reducing wind, a planting should be three to eight rows wide.

The spacing between rows is important to the growth, longevity, maintenance, and effectiveness of a windbreak. Standard spacing between rows is 12 to 18 feet. If large, fast-growing trees are used, they should be planted at a minimum of 20 feet from slow-growing species. Spacing within the row will vary with species. Shrubs are typically spaced 4 feet, while most tree species are 10 to 16 feet. Remember, these are guidelines because actual spacing will be assigned by the resource professional designing the project. Each planting is different and must be designed on an individual basis taking into account all variables posed by the site.

Within-row spacing dictates windbreak density, which in turn determines the effectiveness of the windbreak. Windbreak density is the ratio of the solid portion of the barrier to the total area of the barrier. A windbreak density of 40 to 80 percent provides the greatest area of downwind protection. The density of a windbreak should be adjusted to meet the primary objectives of the landowner.

PLANTING REQUIREMENTS

Successful establishment of a windbreak, or any planting project, requires that the planting site be properly prepared, the planting stock be handled carefully, and the proper planting method be employed.

Site Preparation

Soil condition and existing vegetation on the planting site will dictate activities needed to prepare the land for planting. A natural resource professional can prescribe appropriate site preparation treatments. Site preparation should begin well in advance, and in some areas of the west, as much as one full year is needed. In an ideal situation, the planting site is prepared in autumn and planted in spring. Site preparation involves two actions: 1) eradication of competing vegetation and 2) loosening of the soil to enhance seedling root growth and water infiltration. Turning the ground, either by tilling or disc, will accomplish both activities, or it may be necessary to incorporate a herbicide treatment to eradicate hardy competing vegetation.

Planting Stock

Seedlings must be kept cool and moist, and have oxygen. Most tree nurseries pack seedlings in plastic bags with some type of "wetted medium" to provide moisture, and place them in a sturdy box for transport. Shipment and pickup of seedlings should coincide as close to the planting date as possible. If the seedlings must be stored for an extended time of 2 or more days, they need to be placed in a cold storage unit until the day of planting. Seedlings must be kept cold (33°to 35°F) and not allowed to dry. Tiny roots vital to uptake of water and nutrients dry very quickly; once they dry, they die, and the seedling will not survive after planting.

Method

Depending conditions and accessibility of planting site, seedlings can be planted either by hand or with a planting machine. The method by which seedlings are planted will vary depending on soil type, topography, financial resources, availability of machinery, and size of planting stock.

MAINTENANCE

Once planted, regular attention must be given to the planting to control competing vegetation, to provide supplemental water if necessary, and to monitor for pest and disease problems. As trees and shrubs mature or die, removal and/or replacement may be necessary.

Vegetation Control

All new plantings need unabated access to adequate water, nutrients, and sunlight to become established and attain their optimum growth potential. Therefore, the area around seedlings (2-4 feet) must be kept free from vegetation that competes for both above and below ground resources. Several methods are effective in controlling weeds.

Fabric mulch (a woven, water permeable material) is an effective barrier against weeds and is used extensively throughout the Great Plains and western states. Properly installed, it will provide adequate weed control for several years. Often times, a combination of herbicide and mowing is employed to control competition. Herbicide will control competition *within* the row, while mowing will control competition *between* the rows. The drawback to mowing is that it encourages the growth of grasses that can become difficult to control. Another option is to plant groundcovers between the rows that are non-invasive and easy to control.

Supplemental Actions

Under drought conditions, supplemental watering is highly recommended. This will require appropriate machinery and a source of labor, but cannot be overlooked because it protects the planting and the investment. Also, if soil analysis indicates nutrient deficiencies, application of fertilizer may be warranted. If rodents and deer are a problem, various plastic guards are manufactured, and when installed, protect tender shoots from browse damage.

Density Modification

Tree windbreaks are typically planted at a spacing of 10 to 16 feet within the row to form a functional barrier as soon as possible. As trees mature, they begin to crowd and compete with one another. Some species, such as Eastern redcedar (*Juniperus virginiana* L.) can tolerate this, but others cannot. Some hardwood species and most pine species do not grow well when shaded by others and will die if they remain in such conditions. Thinning the windbreak or systematically removing selected trees will ensure continued health and vigor of the planting.

Sometimes, nature does its own thinning. Insect or disease outbreaks will kill individual plants or entire portions of a planting, leaving voids in the barrier and decreasing its ability to function properly. If voids do occur, they should be filled. Seedlings or larger stock can be used to re-establish trees in the voids, or it may even be more cost effective and beneficial to the landowner to plant another row of trees or shrubs.

OTHER AGROFORESTRY TECHNIQUES

Living Snowfence: A Modified Windbreak

A living snowfence is a tree or tree/shrub planting established with the primary purpose of keeping blowing snow from drifting over roadways and work areas. Living snowfences can be a single row or multiple rows. Often times, wildlife goals are incorporated into the design by planting food plots between the rows and grass for nesting and cover.

Anywhere winter winds create snow drifting problems is a place for living snowfences. Places like homes, schools, shopping centers, emergency service facilities, and industrial parks can incorporate living snowfences in the landscape and save money. Snow removal is costly, and particularly for large areas, the need to pile the snow presents yet another problem. A living snowfence will work to capture and drift snow away from the protected area and reduce the need for snow removal.

Slatted wooden snowfences are commonly used throughout communities as temporary control structures. They must be put up and taken down annually. Table 2 is a cost comparison illustrating living snowfences can save money compared to slatted snowfence.

Table 2. Cost Comparison of Living Snowfence to Wood Fence.

Fence Type	**Average Installation Cost**[1]		
	per linear foot	per mile	per mile over 50 years
Living Snowfence	\$3.10	\$16,368	\$327[2]
Slatted Fence (wood)	\$1.38	\$7,286	\$1,457[3]

1 Installation costs for one course for slatted fence and average of three rows for living fence. These figures do not include maintenance costs because they may vary considerably.
2 Average life of 50 years; not replaced
3 Average life of 5 years; replaced 10 times

Significant savings in fuel and human energy can be realized if living snowfences are planted. The planning process needs to consider many variables prior to planting, including prevailing wind direction, available planting space, layout of area to be protected, and desired secondary benefits. Improperly designed, a snowfence can create costly problems.

Riparian Buffer Strips

Riparian, or stream edge, situations can benefit from another agroforestry technology called a riparian buffer strip (RBS). The purpose of planting a RBS is to intercept both surface and shallow subsurface ground water as it drains off the landscape and before it reaches the waterway - thus saving the energy associated with building and maintaining structured stormwater management and filtration systems. Roots of the tree, shrub, and grass components of a RBS work to absorb excess lawn chemicals (nitrogen and phosphorus). The above-ground biomass absorbs energy (slowing water velocity) and traps soil particles suspended in the water, thus "cleaning" it before it enters a stream or drainage system. Riparian buffer strips improve water quality, help clean the air, provide wildlife habitat, and cool communities through the natural function of evapotranspiration.

The design of a RBS varies depending on site conditions such as soil type, slope, aspect, drainage patterns, and landscape objectives. Installing a RBS planting is no different than planting a windbreak, living snowfence, or any other row planting. However, the maintenance is somewhat more intensive. Usually, fast-growing tree species are planted and some biomass may need to be removed periodically. Most fast-growing species coppice, or sprout, after cutting and this eliminates the need for replanting after the biomass is removed.

For those who live in metropolitan areas where firewood is expensive and landscape mulch is in demand, the harvested material can be used. Properly designed and managed, riparian buffer strips planted along community waterways put trees to work, providing benefits to humans and the environment.

CONCLUSIONS

Windbreaks can be planted to save energy, improve work area conditions, control drifting snow, reduce noise levels, filter dust, and produce secondary benefits such as wildlife habitat, increased property values, and social benefits. Windbreaks also effect microclimate conditions.

Local natural resource professionals should be involved in planning windbreaks around homes, neighborhoods, and communities. They provide the expertise necessary to guide the process of design, establishment, and monitoring.

Planting tree windbreaks is good for the environment and good for people. They are economical and will provide years of loyal service.

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SHELTERBELTS AND SHADE FOR RURAL COMMUNITIES

Katie Himanga, Heartwood Forestry

LESSONS FROM MINNESOTA RELEAF

Practical information is offered here based upon insights from dozens of projects in smaller cities. The resulting checklists offer sound advice to communities of all sizes on setting up maintenance programs.

In 1992 and 1993 the Minnesota Department of Natural Resources, Division of Forestry, implemented Minnesota ReLeaf, a tree planting for energy conservation grant program. Through the ReLeaf program, 49 cities or organizations received grants for projects in 52 southern Minnesota communities. Projects fell into four general categories: shelterbelts, strategic planting for shade, tree canopy cover, and land purchase to preserve trees.

Shelterbelts

- Montgomery Elementary School. Because the new school is situated in the southeast corner of the school grounds, ample room is available for a shelterbelt that extends along the west and north boundaries of the property. The idea of a shelterbelt came up early in the school planning process and thus was a part of the overall concept plan for the school and grounds.

- Prairie Country Resource & Conservation Development Area (R&D). The board of directors of the R&D recognized the need for community shelterbelts ahead of the ReLeaf program. They set a goal of one community shelterbelt in each of the nine counties they serve. When ReLeaf funding became available, they were able to react quickly. The R&D worked with County Soil & Water Conservation Districts (SWCDs) to identify potential projects and assist local communities in applying for ReLeaf funding.

- Lake Wilson. The shelterbelt planted to the west and north of the community was devastated by tornados in the summer of 1992. The community sustained a near 100% loss of tree cover in the western half of town, including the loss of a former nursery that protected some areas from winter winds.

Strategic Planting for Shade

- Rochester. The Greens, citizen environmentalists in Rochester, coined the simple phrase "West is Best" to educate homeowners about strategic planting for energy conservation as part of their project to plant trees to the west of houses.

Overall Tree Cover

Some efforts were thinly disguised, business-as-usual tree planting projects. Even these have value if an energy conservation benefit is realized. A tree planting project can become an energy conservation project as simply as modifying some tree species and planting locations. For example, St. Peter, Elgin Elementary School, and Mankato planted street trees or established tree cover in open schoolyards or parklands.

Land Purchase to Preserve Trees

- Quarry Hill Nature Center, Rochester. The fast-growing city of Rochester is forestalling future heat island concerns by pro-actively acquiring areas of valuable tree cover.

MULTIPLE REASONS FOR TREE PLANTING

Energy conservation does not sell the idea of tree planting in rural Minnesota. People are skeptical. Rural Minnesotans have specific, straight-forward reasons for planting trees where they do: to control blowing wind and snow, because the yard or house is hot, and because they like to hear birds.

For example, in 1985, the city of Olivia planted a shelterbelt to the north and west of a neighborhood where residents were tired of using snow shovels in the spring to remove topsoil blown onto their lawns from an adjacent agricultural field. Also, through ReLeaf, the city of Heron Lake planted a shelterbelt to the northwest of a neighborhood where snow drifting into the street is so severe that it is so difficult to keep the street cleared of snow and public safety is a concern.

Despite the fact that energy conservation is not at the top of the list, most reasons people plant trees are compatible with energy conservation. To achieve energy conservation benefits, other motives must be recognized and affirmed. In Lake Wilson the shelterbelt is not planted so much for energy conservation as to lessen the physical discomfort of winter winds, to replace destroyed trees, and because shelterbelt trees are a part of the community identity.

KEYS TO SUCCESS

Trees are Infrastructure

The common element in communities that have good tree management programs is a person in the community, preferably on the city payroll, who *believes* (not just pays lip-service to the idea) that trees are a part of the infrastructure of a community.

Land

Shelterbelts are the number one community forestry need in western Minnesota communities. To establish a shelterbelt, land is essential. Land acquisition costs more money and causes more headache than planting the trees that comprise the shelterbelt. The city should either own or have an easement for the land on which a shelterbelt grows. Adjacent property owners seldom donate land for community shelterbelts, and when they do, problems may result.

- Fairfax. In 1985, a landowner donated land and money to plant a shelterbelt west of a neighborhood, adjacent to a city street. Several years later he built a house in the belt and sold off other building lots within the belt. But, punching holes in a shelterbelt is unwise, because the wind accelerates through it. Residents in the houses within the belt may have to deal with huge snowdrifts in future winters.

Collaborative Effort

For an effective program, the community should join in partnership with an established organization such as an R&D or SWCD which can provide technical assistance and expertise and energy conservation information.

Tree Maintenance

Systematic maintenance of existing trees is important for safety, cost savings and aesthetics. Maintained trees live longer than neglected trees. Proper maintenance can minimize removal and replanting costs. A systematic maintenance program provides an aesthetically pleasing environment. Healthy trees that are regularly pruned enhance the attractiveness of a community.

On a limited budget, it is necessary to prioritize and then phase systematic maintenance over several years. The prompt and routine care of trees that pose a potential hazard to people and property is the highest priority of the program. Trees should be surveyed for condition and maintenance needs and this inventory database kept up-to-date. An emphasis on good care of young trees is the most effective means of holding future replacement costs to a reasonable level.

Tables 1--4 were created by the author as checklists for communities developing ongoing maintenance programs.

PROBLEMS TO AVOID

Lack of Accurate Technical Information

Misinformation can seriously impede achievement of the energy conservation benefits of trees. For example, a utility brochure erroneously advocated trees to the south of houses. In the worst case, a nursery told a community to disregard all advice about energy conservation and to plant trees wherever they wanted. Hopefully recent publications about tree planting for energy conservation in Minnesota will help fill the information void and prevent future problems.

Over-funding

Some ReLeaf projects were over-funded, particularly in communities that were devastated by tornados in 1992. Tax money would have been better invested over several years rather than all at once. When a community is given enough money to plant six or more trees for each house in town, some of those trees will land on the south side of houses where they do not belong.

Inappropriate Design

Shelterbelt design can and should be modified to meet the needs of the neighborhood it will protect, so long as it does not compromise on function. Trees need to be planted at the correct spacing and away from buildings, roadways or parking lots so that they solve problems rather than create new ones.

The Force of Nature

Installation of parts of the Lake Wilson shelterbelt was delayed two years by flooding.

Failure to Care For What Already Exists

The powers that be and the citizens of rural Minnesota communities often fail to recognize the value of existing trees in their community. As a result, they fail to care for existing trees or protect trees from harmful mistreatment.

CONCLUSION

To achieve quality community tree planting programs, design to succeed, with the following guidelines:

- plan on a neighborhood scale,
- get people involved to foster a feeling of pride and ownership,
- put enthusiastic leaders together with technical expertise,
- plan a scheduled maintenance program, and
- create an ongoing program.

An investment in tree maintenance is an investment in energy conservation.

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As an independent consultant, Ms. Himanga does community forest management planning, project administration, and arboriculture training for local governments and utility organizations. In 1992 and 1993, on behalf of the Mn DNR's Division of Forestry, she provided Minnesota ReLeaf with program support services including promotion, project review, technical assistance and training for communities as well as project monitoring in two DNR Regions of southern Minnesota. She has a Bachelor of Science in Forestry (University of Minnesota) and is an ISA Certified Arborist.

Table 1. Tree Maintenance Priorities

1. ***Eliminate*** hazardous conditions.
   - Survey all street and park trees annually for hazard.
   - When a hazard is identified, remove the defective tree or parts of the tree or remove the potential targets.

2. ***Care*** for newly planted trees and for unhealthy young trees.
   - Inspect the health of young trees 2 or 3 times each year.
   - Water young trees as needed and maintain 4" of mulch.
   - Treat any noted tree health problems.
   - Schedule replacement of dead trees.

3. ***Monitor and treat*** insect and disease infestations that could potentially destroy a sizable portion of the community forest. Potential threats include: Dutch elm disease, oak wilt, ash yellows, gypsy moth, and Japanese beetle.
   - Conduct disease inspections each June, July and August.
   - Treat problems as needed.

4. ***Train*** young trees.
   - Prune young trees every 1-2 years for the first ten years.

5. ***Prune*** older trees.
   - Prune on a regular schedule of no more than 5 years for older trees.

prepared by Heartwood Forestry, Katie Himanga, Consulting Forester

Table 2. Shelterbelt Maintenance Schedule

Maintenance Activity	Year									
	1	2	3	4	5	6	7	8	9	10+
Water	✓	✓								
Add mulch as needed	✓	✓	✓		✓					
Inspect	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cultivate between rows	✓	✓	✓							
Control weeds within each row	✓	✓	✓							
Seed groundcover of grasses between rows				✓						
Mow between rows				✓	✓	✓	✓	✓	✓	✓
Prune trees to develop a single leader	✓		✓		✓		✓			✓
Prune shrubs for renewal as needed										✓

prepared by Heartwood Forestry, Katie Himanga, Consulting Forester

Table 3. Tree Maintenance Activities

Ongoing pruning:	Remove all dead and damaged branches or whole dead plants. Include plants that were damaged or killed during storms or by vehicles or vandalism. Paint over the wounds of oak trees that were injured or pruned from April 15 through July 31. Leave all other wounds open to the air.
Summer pruning:	Prune for clearance over streets and around signs.
Water and weeds:	Water young trees and shrubs during any week with less than an inch of rain. Remove most weeds by hand. Herbicide may be helpful to keep grass out of the edge of the mulch around planting beds and trees.
Mulch:	Maintain a 4" thickness of mulch around the trees and shrubs. Use shredded bark or woodchips. Keep the mulch about 6" away from the base of each tree or shrub. Maintain the mulch at least 2½′ around each young tree (5′ across). Utilize 2-year old woodchips in new planting to improve soil microbial activity.
Winter protection:	Protect the south side of thin-barked trees from winter sun until they develop rough bark. Use a light-colored guard (such as PVC pipe), paper tree wrap or white latex paint. Protect the trunk of the tree from the ground to the first branch. Install guards or tree wrap in autumn and remove in the spring.
Worker training:	For tree pruning training, hire an experienced arborist/trainer to conduct an annual training session or send an employee to a training session or utilize training video tapes. For summer workers, have a trained, experienced staff person conduct an annual training session.
Disease inspections:	Conducted by a tree inspector (in-house or contractor) certified by the Minnesota Department of Agriculture.

prepared by Heartwood Forestry, Katie Himanga, Consulting Forester

Table 4. Tree Maintanance Calendar

JANUARY	FEBRUARY	MARCH
Winter pruning Hazard tree inspection	Winter pruning Hazard tree removal	Winter pruning
APRIL	**MAY**	**JUNE**
Wash salt off trees in grates and medians while ground is still frozen Remove sun protectors from tree trunks Stake tree planting locations	Plant trees Seasonal worker training Water weekly as needed	Inspect depth of mulch Order mulch as needed Disease inspections Water weekly as needed Weed control
JULY	**AUGUST**	**SEPTEMBER**
Weed control Disease inspections Water weekly as needed Add mulch as needed Summer pruning	Weed control Disease inspections Water weekly as needed Inspect all new trees and shrubs	Water weekly as needed
OCTOBER	**NOVEMBER**	**DECEMBER**
Water young evergreen trees Remove stakes and ties from trees planted before fall of current year Fertilize trees as needed Install sun protectors on young trees with thin bark Inspect rodent guards	Worker training for tree pruning Winter pruning	Winter pruning

prepared by Heartwood Forestry, Katie Himanga, Consulting Forester

TREE POWER: THE UTILITY'S PERSPECTIVE OF TREE PROGRAM PARTNERSHIPS

David Weiss, Midwest Power

INTRODUCTION

This first of three papers looks at successful cooperative initiatives between utilities, non-profits, and local communities implementing tree programs.

Midwest Power is the largest investor-owned electric utility in Iowa. Three years ago, Midwest Power merged with IPS Electric of Sioux City, and later this year the utility company will complete a merger with Iowa-Illinois Gas and Electric of Davenport. When that happens, Midwest Power will provide electricity to nearly 620,000 customers in Iowa.

Midwest Power got started in the tree planting business just a little over 4 years ago. Not everyone in the company thought spending money to plant trees was a good idea; especially the line maintenance people, more specifically, the tree trimming crews. But, when a 1990 state law required that utilities in Iowa include tree planting in their energy efficiency efforts, Midwest Power's program "Tree Power" was born.

THE TREE POWER INITIATIVE

Tree Power has three parts. The first is the greenbelt project, in which a few dollars are earmarked each year to plant trees on company property. The second is the education component, which consists primarily of a tree book aimed at homeowners called *Something Cool You Can Do At Home: Plant A Tree*. A third element of Tree Power is the community matching grants program. This third element - the matching grants program - is the focus of this paper.

The former British Prime Minister Winston Churchill is attributed with saying: "Americans have a great tradition for doing the right thing.....after all other approaches have failed." So, when Midwest Power began the task of developing a tree program, the staff resisted Churchill's perception of the American way, and instead went right to the experts, a young organization known as Trees Forever.

Partnership with Trees Forever

After an initial visit with Trees Forever Co-Founder, Shannon Ramsay, the staff was convinced that a matching grants program was the right approach for Midwest Power. A partnership was born. This partnership would help the company meet the state's mandate to plant trees, while at the same time assist in ongoing efforts to cement relationships with local communities.

For Midwest Power, Trees Forever was the right choice to manage the program on the company's behalf for many reasons. They were young, but Trees Forever had already demonstrated experience and success in developing and delivering matching grant tree programs to other communities in the state. Their goals were similar. They shared a desire to form a coalition in which all three partners - the community, Trees Forever and Midwest Power - were equals. Trees Forever shared a belief that to be successful, these projects must belong to the communities, and not be dictated by Trees Forever or Midwest Power.

At the same time, Trees Forever has demonstrated success in providing the level of program oversight necessary to ensure that projects follow appropriate tree planting as well as community guidelines. For example, the program must make sure that plantings always involve the right tree in the right place; in other words, away from overhead power lines. They have also demonstrated the confidence and integrity to say "no" to ideas and proposals that fall short of minimum standards, whether these ideas come from communities or Midwest Power. This is a valuable commodity that protects and enhances the program as well as the company's good name.

The Utility's Role

The utility company's role is just as important, first and foremost, by bringing financial support to the partnership. Utility dollars not only get things started, but also generate new dollars from the community. Midwest Power also brings a certain familiarity to the process by being well-known in the communities served. Company employees can usually identify a town's movers and shakers, those who get things done, and make sure they receive the grant applications each year.

Midwest Power brings one additional aspect to this partnership, and that is active support beyond the dollars. Area supervisors and management are frequently called upon to participate in plantings and other matching grant activities. They usually respond with genuine and well-placed enthusiasm.

"Well-placed" action is necessary, because, if the program is to remain successful, Midwest Power must keep hands off of awarding of grant dollars. Trees Forever uses a formula to grade each of the applications. Once the grades have been determined, the grant dollars are divided among the communities upon recommendations by Trees Forever.

Participation by the company in that process would compromise it. Allowing Trees Forever to make these determinations based on a system that is judiciously administered ensures integrity, eliminates potential problems and removes the temptation for area managers to attempt to influence the selections. So, Midwest Power keeps hands off.

Partnership with Communities

Local communities provide the third link to this successful tree planting partnership. Communities contribute immeasurably: they grow the dollars, they provide worker/volunteers, they are responsible for developing projects and ideas, and they are very appreciative. This appreciation is usually very widely expressed, in personal notes and letters, in releases to the media and in conversations along Main Street, and this appreciation does not go unnoticed among the company's senior management.

Resulting Actions

As an indication of the impact of the matching grants program, in 1994, 57 grants were awarded totalling - with administration and program delivery - $354,000. Those 57 communities generated an additional $604,000, pushing the total commitment to Tree Power for 1994 to $958,000. Included in this are gifts-in-kind and volunteer labor and an actual dollar match of nearly $403,000. These dollars improved the local environment, provided a positive visual impact, even enhanced utility energy efficiency goals. They also had a positive impact on at least 57 local economies.

The matching grants program had one additional benefit that was not anticipated in its original goals and objectives: the grants were the catalyst that created a climate of community spirit and camaraderie. The grants brought people together, in a common cause. Neighborhoods were mobilized and additional community projects and needs were identified and addressed.

CONCLUSION

Tree Power is a very successful partnership. The communities are well aware of Midwest Power's support and they are appreciative. Together with Trees Forever, the company is helping communities - 64 in 1995 - plant thousands of trees along boulevards, in parks, at city entrances and even in private yards.

From the utility's perspective, the formula for success is simple - find good partners, then stay out of their way unless they ask for assistance. As British actor and comedian John Cleese so aptly stated: "If Churchill were alive today, he'd roll over in his grave." Perhaps he would, for Tree Power has managed to do the right thing first time around.

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KEYS TO NON-PROFIT INVOLVEMENT: THE TREES FOREVER PERSPECTIVE

Shannon Ramsay, Trees Forever

TREES FOREVER - A MODEL NON-PROFIT

This second paper on partnerships gives a non-profit organization's view on how to successfully collaborate in tree planting programs.

Trees Forever works with over 300 Iowa communities involving 25,000 volunteers. Of Trees Forever's twelve staff, seven are field positions, titled community coordinators, responsible for between 30 to 40 communities each.

Sixty-five percent of the trees planted through the utility-sponsored community program have been placed for maximum energy efficiency benefits. Around half of trees planted to date have been planted on private land, including private residences, businesses and nonprofit lands. The community program is provided to communities through an application process. Communities receive a monetary grant and general program assistance from Trees Forever to develop a comprehensive program, not just funding for projects.

People are the key to success in communities throughout Iowa. Volunteers sometimes have stereotypes of utilities and sometimes utility employees see volunteers as "problems". The Trees Forever program in Iowa has created collaborative partnerships between local volunteers and operations employees.

The Trees Forever role is primarily volunteer coordination. Trees Forever was started by volunteers and its mission is to facilitate. *Education, media, fundraising* and *long-term planning* and *care* are the primary areas of focus. Education is an ongoing process, and Trees Forever encourages volunteers to attend workshops presented by Iowa State Extension and to become Community Tree Stewards.

Participating communities leverage their cash grants an average of five times. This includes actual cash, gifts-in-kind, volunteer hours and other contributions.

KEYS TO NON-PROFIT INVOLVEMENT

Successful partnerships place emphasis in four key points:

Leadership

All partners and parties involved need to identify strong leadership to develop and lead the program both at the nonprofit, local and sponsor level.

Organization

Strong organization and follow through are a must for both the development stage and ongoing program administration.

Funding

Adequate funding is a must, particularly for program delivery and education.

Projects

Launching new and interesting projects year to year, both plantings and educational projects, keeps momentum strong. Developing new components to existing programs is also important to maintain involvement and commitment.

NON-PROFIT COALITIONS

Nonprofits involved with tree planting and stewardship are "sprouting" all over. The Alliance for Community Trees is a national coalition of nonprofits, of which both Trees Forever and the Twin Cities Tree Trust are members. Membership has grown from twenty to almost 50 in the last and one half years.

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Ms. Ramsay co-founded Trees Forever in 1989. As President of Trees Forever, she has led the organization to become the largest statewide privately funded nonprofit tree planting organization in the nation. Ms. Ramsay is currently Program Chair of the Executive Committee of the Alliance for Community Trees.

The Trees Forever Iowa's Unique Partnerships video is available for use in promoting utility participation in tree programs with nonprofits. Contact Trees Forever at 1-800-369-1269 for a copy.

KEYS TO EFFECTIVE PARTNERSHIPS

Janette Monear, Twin Cities Tree Trust

INTRODUCTION

This final paper on partnerships links utilities, schools, developers, and communities through seven qualities for success.

The Twin Cities Tree Trust is a nationally recognized nonprofit dedicated to education, employment/training and environmental stewardship. The Tree Trust's program goals are:

- to educate people about the important benefits of trees, train them to care for trees properly, and support them in their tree planting efforts, and
- to train and employ special needs youth and adults in meaningful community projects.

TREE TRUST PROGRAMS

Since 1976, the Tree Trust has been helping to develop communities through its employment and community outreach programs. The Time for Trees program helps people help themselves by giving them the knowledge and confidence to form partnerships that support and expand a greater environmental consciousness. Education and technical expertise are provided to help community groups "Plant for the Future".

United Power Association, Anoka Electric Cooperative and Wright Hennepin Electric fund the Tree Trust's Planting for the Future Program. These utilities also fund both the Time for Trees school and community outreach programs of the Tree Trust. These programs promote energy conservation, provide education and support the utilities' commitment to community development.

Time for Trees School Program

The school program helps schools plan and implement outdoor environmental learning areas on the school grounds. Use of these areas helps schools reach state mandates for environmental education, service learning and community service. Environmental education is moved from the pages of a book in the classroom out into a forest, illustrating the interaction of living systems with one another and the importance of human participation in the resolution of environmental problems.

At each school, planting is done for energy conservation, education, aesthetics and for a "hands-on" opportunity. The Tree Trust provides participating schools with Green Team coordinators, classroom educators, teacher training (Project Learning Tree), manuals and resource materials, planting equipment, plant materials, and wood products (made by the youth employment program).

The Time for Trees school program integrates different curriculum in a very comprehensive manner. The lasting results are education that changes attitudes and paradigms that make change. Through the Time for Trees process, students take ownership and responsibility for the project and ultimately for their environment. They have an opportunity to have a hands-on experience to plant trees and shrubs. They improve their schools, gain pride for their efforts, and learn life skills.

Time for Trees Outreach Program

The community outreach program establishes unique partnerships with volunteer community groups, utilities, builders and developers and other resources that will help participants organize and implement tree planting projects. This interactive program promotes citizen participation in community tree planting projects. Participants gain a greater appreciation of proper urban forest management as a form of environmental stewardship.

The Tree Trust provides funding (including some received from utility sponsors) to community groups through a competitive grant process. The request for proposal has four basic categories: planting for energy conservation, maintenance, forming partnerships, and education. Points are assigned to different high priority tasks that are important when planning and maintaining a planting project. Currently, the community outreach projects include many communities throughout the Twin Cities metropolitan area, but the program will be expanded throughout the state with more utility, corporate and foundation sponsorship. The results of the outreach program are new partnerships, community involvement, neighborhood enhancement, unification of neighbors, community development, and energy conservation.

Planting for the Future Program

The Tree Trust has recently piloted a new project with developer Dave Langseth, Anoka Electric Cooperative and United Power Association. This project is uniting a newly developed neighborhood through planting for energy conservation. The Planting for the Future Program is community development at the grassroots level and is extremely powerful.

The homeowners, with professional assistance through the Tree Trust, are putting together a planting plan that incorporates strategically planted trees for windbreaks and shelterbelts, shading on the west and east sides of their homes, development of a new park area, and overall aesthetic value for their neighborhood. The City of Oak Grove has worked cooperatively, waiving city tree ordinances in order to gain greater tree cover. The neighbors hosted a community wide tree planting workshop at City Hall to promote tree planting in Oak Grove.

Builders and Developers Workshops

Tree Trust is also providing builders and developers education about tree protection, preservation and replanting. A series of workshops at various locations across the state are planned to provide education, continuing education credits and tours of successful preservation sites. This hopefully will bring about changes in practices, behavior and attitudes resulting in better developments, increased home values, and increased awareness of the need to manage natural resources.

Trade A Tree

Trade A Tree is a new program funded by Northern States Power. The goals of this program are to reduce outages and line maintenance costs, while increasing tree cover through the planting of appropriate trees. The results of a pilot project in the southern Minnesota city of Mankato are more reliable transmission systems that are less expensive to maintain, a better educated public, healthier trees, and more of them! The partners in this project included the City of Mankato, homeowners, Davey Tree Service, a local school, NSP, and Tree Trust. Trade a Tree is a win/win project for all partners in Mankato.

SEVEN COMPONENTS IN SUCCESSFUL PARTNERSHIPS

Good community projects tend to have seven common components (the C's) which make them sustainable and a win-win situation for everyone. All partners in projects, as well as relationships, need these "seven C's". They are the key components of good partnerships.

Commitment

Commitment is the most vital part of the partnership. All partners must be committed to working together and to understanding each other's goals and objectives so that expected outcomes are reached. Utilities are looking for public awareness, community development, and energy conservation. They have a commitment to the health and well being of the communities they serve, they have energy conservation requirements, and they are a for profit business so they must do direct and indirect public awareness and promotion. Developers are part of a community's economic growth and to stay in business they must sell homes. Understanding each partner's strengths and trusting in their ability to do what they do best will strengthen the commitment that each partner has for the other. Commitment comes from understanding and it allows for better communication.

Communication

As with any relationship, communication is necessary to keep things moving in the right direction. Communication must be clear, concise, timely, and must flow between all partners. Everyone must understand what is being said to ease communications internally and externally. Internal communication between partners and among those in each individual organization is extremely important. The language of the other partners must be learned to communicate clearly. Good communication is important when reaching out into the greater community to do the advertising and promotion that is needed to reach the goals and objectives of everyone involved.

A good communicator is also a good listener who hears what others are saying. Communication also takes coordination.

Coordination

Coordinating efforts, communication and programs are key to a collaborative effort. Everyone needs to keep on task, moving in the same direction, to meet the outcomes. The more coordination, the less redundancy. Coordination identifies timelines and tasks that need to be met and assigns those tasks to the proper partner. Coordination of the partnerships also identifies where compromise needs to occur.

Compromise

A compromise is a settlement in which each side makes concessions. In order to compromise, everyone must solicit input and be flexible. Collaborations require compromising so that everyone's objectives are met. All partners need to feel that the partnership is fair and equitable. Changes need to be made, but should never compromise the quality or high standards that are expected from the project.

Consensus

Consensus is the collective opinion reached by the group as a whole. It finalizes thought processes and attitudes and moves the project into an action process. After consensus, things move forward and everyone feels comfortable with the direction of the team. When consensus is completed, teamwork or cooperative effort increase.

Cooperation

Cooperation is working together to a common end. Many challenges face people working in partnerships and implementing programs. Cooperation to find a solution to those challenges and successfully overcoming them results in everyone having a part of the success of the program. A win/win partnership builds upon itself making it easier to partner again.

Congratulations

Celebrate success! Gratitude should be expressed for all the effort and time involved. Congratulations also advertises the success of the program and makes people feel their time and efforts were valuable contributions.

CONCLUSION

The lasting results of good partnerships are good programs where everyone wins. Working together to enhance communities, educate, and teach life skills (like tree planting and land stewardship) are concrete benefits to the communities, the people, the utility, the developer, and the nonprofit. Partnerships are like any relationship, it takes all of the seven C's: commitment, communication, coordination, compromise, consensus, cooperation, and congratulations. When the effort and time are taken to build the partnerships on trust and hope for the betterment of the communities, partnerships will be a win/win situation. "Let's all sail the seven C's together."

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INTEGRATING SUSTAINABLE HABITATS INTO THE DESIGN OF COMMUNITIES

Ben W. Breedlove, Breedlove, Dennis & Associates, Inc., and Larry L. Peterson, Florida A&M

INTRODUCTION

The urban environment is the largest under-managed ecosystem remaining in the United States and, increasingly, one of the most necessary for the continued well-being of many species. Utilities, governments and individuals are increasingly working together to achieve the mix of economic, ecological and community values that are available, but unrealized, in the urban environment. Animals, the other mobile members of urban communities, can best tell people how to achieve these ends.

Situation

This closing essay further expands the idea of the Power of Trees by challenging people to plan for wildlife as co-inhabitants of communities.

The urban forest is essentially a large system primarily receiving management on a tree-by-tree basis. Urban forest inventories are essentially location, health and well-being inventories. As a consequence, such inventories do about as little as can be done. Most urban foresters spend too much time on tree problems from a homeowner's perspective or from a damage prevention standpoint, and almost none dealing at a habitat or ecosystem level.

Humans tend to move about under the canopy with a "TV view" - eyes locked ahead. Jogging is a goal. The dog's recreation is a goal. Like most tribes, urban dwellers can only appreciate what they understand and incorporate into their value system. They tend to want a lot and understand a little.

From a non-human user standpoint, the urban forest is much different. Life requisites - food, water, and other essentials - are scattered. Core habitats exist far from the urban core. For example, food for wildlife either tends to be over-abundant or not available at all. Horticultural plantings are chosen for human visual pleasure rather than to provide any requisites for non-human occupants of the cityscape. The planning effort that is customary for human activities does not have a comparable effort for non-human users of the urban and suburban landscapes. It should.

Energy efficiency analysis and management tools offer an opportunity to accommodate both human and non-human needs in an increasingly integrated fashion (Forester, 1969). Incentives to not consume and to produce differently will drastically affect people's ability to manage for multiple outcomes (Hawken, 1993). Political and economic shifts in national priorities will require improved accountability and effectiveness in spending. Shifting perceptions of the urban/suburban/periurban forest will help achieve all of these goals in a mutually beneficial manner.

Response

The role of the urban forester can change now to better meet a multiplicity of goals. Current technologies, such as Geographic Information Systems (GIS), Global Positioning System, data loggers, bar code readers and laser range measurers and information management systems such as ArcView 2, are powerful and affordable. Proper utilization of these tools will allow many changes to occur at once in a manner that decreases budgets while increasing effectiveness significantly (Breedlove, 1994). Field personnel with few qualifications can be trained quickly to operate the equipment and collect data properly. Highly trained personnel can spread their efforts over a larger area. The management emphasis can shift from problem tree management to ecosystem management, with tree management as a routinized subset of the GIS-based management system.

People typically do not have the visual skills nor the information background to understand the multiple values of the urban forest (Gobster, 1995). Functionality is often invisible. People have to be told where and how to look to become aware of many of the values and functions of the urban forest. Including these new views and values in their repertoire of skills is one of the cheapest things that can be done to increase the value of the urban forest. Education and involvement of the public, as well as multi-disciplinary cross-training of participating groups is imperative, if society is truly going to use the power of trees for the benefit of human and nonhuman users.

From the standpoint of the non-human species the situation is quite critical, not in any crisis related sense, but in a functional and educational sense. The problem is that the value of the urban forest is a matter of user votes. The variety and number of successful user species are the measure of the true value of the urban forest. How well the urban forest delivers its goods and services is quantifiable to and for all user groups (Brand, 1995).

Urban planning, as currently practiced, is single species planning. It responds to demographics. Natural system planning is multi-species planning (U.S. Fish & Wildlife Service (USFWS), 1980). It is several times more complex. It receives several times less effort. Typically the leftover or "unplanned" area is the natural system's planned place for sustenance and occupancy, without regard for demographics of non-human user species. Correcting this is quite simple and very amenable to computer-based management (USFWS, 1926 - 1984). Developing a local or regional set of conditions has to be done at least once. Subsequent reapplication is very cost- and time-effective, and will drive very different, but much more useful and meaningful, planning, planting and maintenance efforts.

The utilitarian efficiency of the urban forest and its consequent power is derived from applying energy-based ecological analyses to all human activities (Odum and Peterson, 1972; Peterson, 1978; Odum, 1973; Peterson, 1974). The analysis of potential benefits (including cooling of the urban core and provision of social benefits such as places of respite for human or other users), and improving management directives through understanding of ecological energetics (Forester, 1969) are fundamental starting points for effective design and management of the urban forest. Current hardware, software and associated tools allow energy-based ecological analysis to be fully integrated into managing the urban forest in response to the votes of all the potential users of the system.

VIABILITY AND VALUES

Viability can be measured both in energy terms and in habitat terms. Energy efficient landscapes for people can be viewed in many different ways. Management of energy efficient landscapes must be done on a component-by-component basis.

However, design of energy efficient landscapes must be done as a multi-component exercise and done at one or more scales larger than the problem or design unit. Human viability design often does not consider subsidies that affect true sustainability and efficiency. Design for the non-human users of human dominated landscapes typically fails to a much larger degree to include these same considerations. However, excellent bases for natural system design do exist and are reasonable to use (USFWS, 1980).

Consideration of and design for non-human species usage will result in a more habitable and sustainable landscape for humans. It can provide the aesthetic values of current horticultural landscapes. However, a better sense of place will be created than in current designs. The severely urban core hardscape will contrast more strongly with the redesigned suburban softscape or ecoscape where ecological design and environmental psychology combine to produce a livable landscape for a mix of species and humans. A deliberately managed viability will result with a sound subsistence base for species most likely to have their life requisites met (USFWS, 1980).

A shift is essential from the horticultural or scenic values of the past decades to a managed landscape meeting the entire needs of all species. This only succeeds when people recognize the needs of other species and to bring those needs into the human system of values. This is particularly necessary for the economic system.

Other animals must be given the opportunity to experience the human dominated landscape and find where their needs can be met. For example, least terns in west Florida now nest on the tar and gravel roofs of commercial buildings (Gore and Kinnison, 1991). Their preferred natural nesting locations (their niche or habitat) are the sandbars adjacent to drainage cuts from interior lakes. But, this niche location is a preferred play location of humans. Although the tern is on the Endangered Species list and up to forty percent of the nesting of the terns now occurs on these roofs, no analysis or assistance has been provided to improve this created habitat component. Observed stress behavior of the adults following heavy rains suggested that flooding on the roofs may be harmful to reproduction. Follow-through is needed to increase productivity of these new urban habitats in order to manage populations at achievable levels.

The contrast and conflict between symbolic values and viability occur most strongly in the regulatory arena and the associated public debate. Frequently altruistic behavior labeled as good or right is neither (Hawken, 1993). "Preservation" should always be written in quotes.

For example, avoidance or replacement of an impacted wetland with an "on-site in-kind" wetland is probably the least acceptable alternative when the larger surrounding area is, in all probability, in the path of development. This practice is rooted, in part, in the false public belief that development is without impact if it avoids wetland contact, thereby, "preserving" it. But in isolation, the "wetlands are valuable" refrain is dangerous and counterproductive particularly in the developing environment. An alternative to the original or native landscape is likely a better habitat than retaining the original within an area undergoing development. Furthermore, a fundamental wildlife management concept is that that scarce landscape types, rather than abundant, should be of higher consideration for increased wildlife value. Adding more of the most available habitat components is like planting more pines in a pine plantation and calling it better habitat.

THE DESIGN PROCESS

Conceptual design which looks inclusively at the inhabitants of places allows a minimal planning and design effort to effectively include many other associated species (USFWS, 1980). Kids, cats, dogs and cars own the surface layer of the urban forest. In contrast, ecosystem-based design must emphasize what is in and just below the tree canopy. Success requires that design incorporate the other species value systems. Humans need to understand, recognize, and value the life requisites of other species, if they truly intend to have them around. Other species need to be given the opportunity to adjust to humans and find their necessary mix of goods and services.

Knowing Species Life Requisites - Range and Pulse Analysis

Range and pulse issues force thinking about the spatial requirements of species and the partial uses of a habitat. Some species have a small, limited geographic range, and complete their pulses or life cycles within very small areas. Other large-range species, including those that migrate, may occupy a given area for only a short period of time and only for a very specific purpose.

In the typical urban forest patch ecosystem, some species find all their life requisites, while others utilize the fragmented urban terrain, either skipping from one isolated patch of habitat to another or moving along remaining linear habitats such as riparian stream corridors. The major urban landscapes of the United States are concentrated along major migration routes (including the coastal areas and the Mississippi River flyway), making it particularly necessary to incorporate these migration pulses and partial habitat uses into design of the urban forest.

For example, monarch butterflies move through the Florida panhandle on their annual migration. For them, it is a necessary location for a brief, but essential, period of time. It is also long enough for the humans to have a festival celebrating this natural event. The humans have taken the natural system functional value recognized by the animals and assigned it a "sense of place" in the human value system (Alexander, 1979), thereby "preserving" it within the context of positive human value system incentives. If an area, like the panhandle of Florida, serves only a narrow, but essential function, valuing that locale expressly for that habitat component is necessary.

A pulse and range analysis makes people think inclusively about particular species and their needs and, in essence, requires design to be of appropriate size and scope. This design step is essential for successful management of an issue. The output of this scoping step is a list of species for which partial or complete management is possible and a set of definitions of the life requisites for user species in the area selected for management. This information becomes a functional shopping list for the creation of very utilitarian, high value habitat components having a greatly increased likelihood of being used in ways that increase the successful retention of species of interest. This pulse and range analysis can also serve as a basis for allocation of management efforts among the various human governmental and social entities responsible for maintenance of species. Thus, groups with small areas of management responsibility can effectively become players in larger scale habitat management efforts.

Habitat Planning

The next level of thinking and action necessary for success is habitat planning. Habitat has been defined as the provision of food, cover and water. This definition works in traditional, large management areas where improvement of existing and functional habitat is the goal. This definition may also be used successfully in other areas where providing food, cover and/or water results in the occurrence of additional individuals. The success may be misleading, however, when additional resources are not in balance with the habitat from which these animals were drawn.

Habitat must contain a sufficient quantity and quality of all life requisites of feeding, breeding, nesting and resting opportunities (USFWS, 1980). For example, people think they like to have butterflies in their yards. But, really they like to have the adults. The caterpillars chew up things, they don't look too good, and a chrysalis isn't too exciting either. Butterflies need a place as adults to get out of the way. This resting place can be a long narrow box with slits in the sides so they can go through with folded wings. It is our obligation to provide all life requisites, which must be suitably juxtaposed in time and space for all life stages. Figure 1 suggests one set of spatial juxtapositions, indicating feeding (F), breeding (B), nesting (N), and resting (R). In an intensely managed situation, including all urban and periurban environments, these habitat components and their time and space relationships take on added significance.

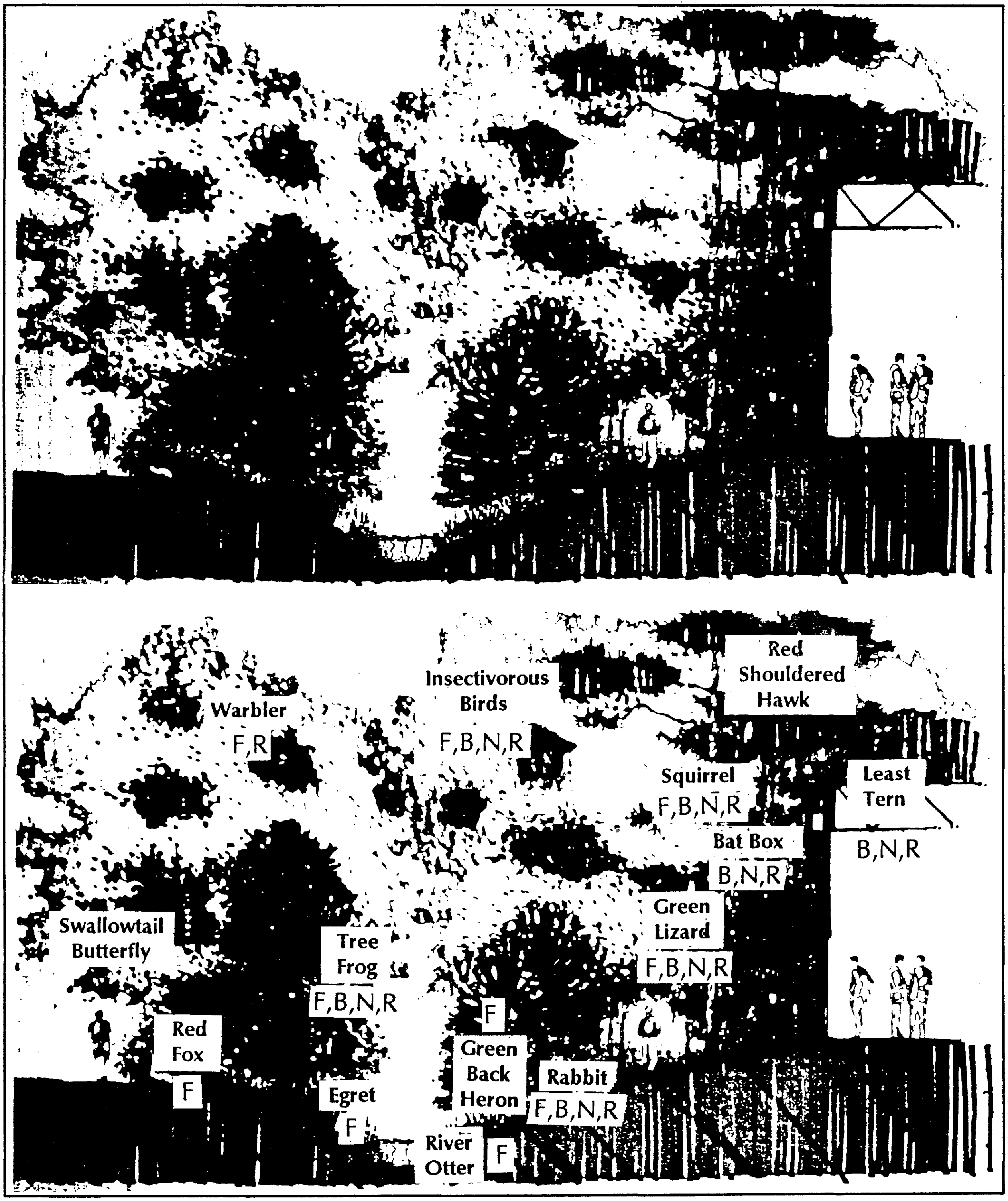

Figure 1. The visual aspect of an urban habitat (top) and a functional aspect of the same urban habitat (bottom). (F=feeding, B=breeding, N=nesting, R=resting).

Most of what is needed for incorporating wildlife management into the design of urban forests is already known and readily available. The Habitat Suitability Index Models (HSI) (USFWS, 1976-1984) are excellent bases for true design of functional habitats for a large number of species. They are also useful for deciding which species can be successfully managed on a given area and the extent to which cooperation will be needed for successful management. The associated Habitat Evaluation Procedure (HEP) (USFWS, 1980) is available as manuals and as software. While this procedure was intended as an evaluation technique, it contains the factors necessary for design of high value functional habitat. Because the procedure as software can be modified, the urban design process for animals can be a standard part of the human habitat design process. Also, similar to other design processes, efficiency is gained through usage because the models, when regionally adapted and incorporated into a GIS, become a standard part of the culture of design.

Shifting to a "top down" approach, both in terms of canopy-down planning and top-of-the-food-chain-down planning, will radically alter the habitat design process and its outcomes. All current values will be accomplished at current costs and efforts. Operational efficiency will increase significantly with only a nominal increase in initial effort.

Extremes in fire, disease, and cold, as well as habitat losses elsewhere, result in chokepoints killing off a part or all of a population. Thus, successfully functional habitats need to have the species pass through a chokepoint successfully. A habitat area suitably isolated from the disturbances would ideally be a "core habitat". Such a habitat would be sufficiently large and intact, and suitably buffered to survive passages through chokepoints on its own. Ideally, the core habitat would be connected to the area under management, so that repopulation could occur without human intervention. Increasingly, however, human transport of species or their genetic material will be a necessary substitute for natural movement patterns in the urban and periurban landscape.

Impediments to Habitat Planning

Homo sapiens var. conventionalis is the exotic species in the system most likely to prevent the successful design and implementation of the true power forest. This stability-seeking, change-resistant life form operates by two primary means: the first is inertia, the second is by regulatory fiat.

The former can be dealt with by creating urban forest habitats and slowly increasing their place within societal value systems. The latter form of resistance is both the most dangerous and the most useful. Because *H. sapiens var. conventionalis* typically occupies its habitat without being subjected to the same survival forces acting on more exposed organisms, it tends to mentally burrow in and insulate itself from disturbances. Use of logic within such a system will not result in much change. Success in creating the effective urban forest will come when the economic processes and the voting community demand that habitat compensation for impacts be viewed on a functional basis. Instead of trading area for area (replacing native habitat with the same acreage of created habitat) and using the current criteria of "avoidance" and "on site - in kind" replacement, the functional approach would give the ecosystem a bigger bang for the buck.

Business is an ethical act, but the language of commerce is only beginning to include the terms that allow it to incorporate some of the environmental cost accounting expected of it (Hawken, 1993). Ecological economics (including energy based accounting and design criteria) is only now beginning to be applied (Odum and Peterson, 1972; Costanza, 1991; Daly, 1991). Higher-level city designs and governmental designs need to follow sound ecosystem and energy bases (Peterson, 1978), so that the power of trees can be obtained at the scale of the problem. Then, cities will be habitable for humans in the best sense and use of that word (Alexander, 1979).

THE SOUTH WALTON COUNTY CASE STUDY

A planning project for 55,000 acres in Walton County, Florida can serve as an appropriate case study. The South Walton County Conservation and Development Trust (SWCDT) was created to direct an analysis of the potential to integrate conservation and development in south Walton County, Florida. The area has been voted as having the number one beach in the

United States each of the last two years. The primary user groups have been a local regional clientele and a military presence. The beaches are beautiful and development has been a mix of conventional small scale activities with an accelerating tendency toward typical tall condo buildings. The area also includes Seaside, a neo-traditional beachside community based on pedestrian-scale activities and a market complex offerring unique products. Large-scale land purchase by the state as well as public concern over the future quality of life in the area were the impetus for the study.

Several conditions for the study were unique. First, the planning team was to assume no ownership patterns for the area. Consequently, all parcels were up for grabs, so redisposal would optimize the long-term ecological and economic potential of the 55,000 acre study area.

Second, criteria for development and for conservation were to be addressed separately, then conflicts identified and resolved. Third, the process and product were to occur essentially in a paper-free (electronic) working environment using primarily existing data. Public participation included a design charrette (workshop) facilitated with GIS to provide real-time incorporation of criteria.

Fourth, the natural system end-users (non-human species) participated on a comparable footing with the humans through a) incorporating data from the Florida Game & Fresh Water Fish Commission on Biodiversity (Cox, Kautz, MacLaughlin, and Gilbert, 1994), b) addressing threatened and endangered species and functional use areas within the study area, and c) applying the HEP/HSI habitat models for species likely to use the area and for some species believed to require larger areas than the study area or its primary sub-components. These data and analytical processes were played against the project themes of "ecology, economy, community" to produce a recommended development and conservation pattern for the area epitomizing these themes.

For the study, the cumulative presence of species of interest was used as a measure of conservation value, while a similar concentration of development parameters indicated desirability for development. The combination of these two gradient profile maps gave an idea of the location and extent of compatibility or conflict between the two proposed types of uses. From these maps and patterns town centers could be located and sized, as could conservation areas. The long-term development and economic potential of the area could then be assessed in conventional terms.

Of utmost interest in the study was the ease and clarity with which humans and the animals were shown to be in conflict or not in conflict. Conflict tended to occur where sites with high value for human development sites coincided with habitat of threatened and endangered species. For example, the highest, driest best dune areas were priority development sites. For the same structural reasons, these sites also contained unusual numbers and types of threatened and endangered species. Conversely, potential for conflict between conservation and development was minimal in areas costly for development due to adverse site conditions such as high water tables, flooding potential, or distance from roads.

THE URBAN ANIMALS SPEAK BRIEFLY

The design tools mentioned materially assist in shaping the urban ecosystem or in preventing unnecessary damage. But, the animals can speak through their actions of accepting both expected and unexpected urban landscapes to show where they are effectively considered and when and how to do better.

For example, many wetlands deliberately designed for regulatory requirements do not get significant animal usage. These relatively expensive wetlands are planted with large trees at the outset. Every offending weed is carefully pulled by hand for a period of a few years. Attempts to set things right are done in a "human-scale hurry" within a system operating on a much longer scale that does not respect this short synapse effort. The result is a dense stand of agency-approved vegetation minus any significant complement of higher level user species. Efforts are lavished on annually counting and tagging every tree planted on its very natural five foot center.

Instead, much less could be spent in a less regulatory approach. The animals should have a voice. Because, when the animals vote, they do so in a very obvious manner: they *use* the resource. Looking at these uses, particularly within the urban ecosystem, is the fastest way to supplement the existing literature and the HEP/HSI habitat procedure manuals and gain approval of modifications from urban-adapted animals.

Several lessons can be learned by looking at a particular freeway interchange in Florida. Within the interchange, alligators and turtles have claimed a sunning spot on the only piece of canal bank not visible to passing vehicles. Viewsheds (what people see or not from a vantage point) are designed for people (Bacon, 1995). In this example, the animals found the artifact occurring in the system that was the exact opposite of the viewshed that a human might prefer. This is a good example of communicating with the species most likely to conflict with humans. How many of these functional additives are needed to stabilize the available population and where should they occur?

On the other side of the same overpass is a blackbird roost site. Here birds have modified a stormwater management pond to improve its value to them. The cattails on the fringe are taller for about the distance a predator can jump. This tall vegetation also doubles as a windbreak to help create a beneficial microclimate in the roost at night. The interior has a high percentage of bent-over cattails creating a roost platform and contributing to the roost area microclimate.

A stormwater impoundment on the other side of the overpass serves as a water bird-feeding area. The dry bottom pond, covered with grasses, has essentially a terrestrial insect population. Runoff isolates the insects and makes them easy prey for the birds.

Yet another example is a stormwater treatment pond filled with *hydrilla*, considered one of the worst water weeds in Florida. However, *hydrilla* is also one of the best generators of freshwater shrimp and other food. It is dependable as a food source and is a high-level producer. The *hydrilla*, in combination with the edge vegetation and relative freedom from predators, converted this stormwater treatment pond into the most productive nursery for the common moorhen the author has seen. The animals have added feedback forces. Trails crossing the area are about twice the striking distance of the birds when feeding. This assures a 100 percent coverage of the vegetation mat and a relatively thorough harvest with minimal effort. Here fast food take on an entirely different meaning.

If these are indicative of uses made of the artifacts in the human environment, how about one use in the deliberately constructed, standardly planned part of the truly human landscape? The woodpecker who has made a nest on a wooden light pole has 24 hour-a-day outside security lighting, reasonable access to a paved road, a carefully located house site, an ocean view, reasonable access to his human neighbors, and seems to be relatively happy anyway.

CONCLUSION

The focus here on higher animals is deliberate. The higher-level species assure that the vegetation types, quantity and areas planted will have ecosystem utilitarian value. If environments are designed for them, other species will be carried along without having to do much, if any, additional work.

Communities can be designed and managed so that they truly meet the realized and currently unrealized needs of humans, *and* provide for many other species, as well. In so doing,all will gain the true power of the urban forest.

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