LCMR WORK PROGRAM: Status Report: June 30, 1993

I. **Tree and Shrub Planting for Energy in Minnesota Communities--Energy 3**

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A. M.L. 91, Ch. 254, Art. 1, Sec. 14, Subd. 13h

Appropriation: $1,250,000
Balance: -0-

This appropriation is to the commissioner of administration for a grant to the commissioner of natural resources to develop research-based guidelines and publications, and to provide matching grants for energy conservation tree planting. $950,000 of this appropriation is available only as cash flow permits.

B. Compatible Data: Not applicable.

C. Match Requirement: $959,250
Funds Raised to Date: $900,000 (approximately)

The cost-share portion of the program is to be matched by participating local communities.

II. Narrative

Reductions in energy consumed for air conditioning and heating will save Minnesotans money, will reduce the need for power generation and new power plant construction, and will improve the quality of life by reducing carbon dioxide emissions and acid rain resulting from power generation. As stated in the 1990 Report to the Minnesota Legislature by the Minnesota State Shade Tree Advisory Committee, the value of trees for energy conservation has been demonstrated for other regions: up to 30% reduction in air conditioning costs and 10-25% reductions in costs for heating. Minnesotans already spend millions on landscaping, often with minimal energy savings realized. Instead, through this project, people throughout the state will see returns on their investments in plantings through reduced fuel and electric bills and through more comfortable buildings in an improved environment.

Furthermore, this program will accelerate appropriate planting of trees and shrubs for energy conservation in Minnesota communities by: (1) developing research-based guidelines for the most effective plantings; (2) increasing the availability of up-to-date information (publications) regarding energy efficient planting; (3) providing cost-share funds for community purchase of planting stock; and, (4) establishing a network of volunteer organizations to plant and maintain the landscape materials.

III. Objectives

A. **Quantify benefits and develop guidelines for effective energy conservation plantings.**

1. Narrative:

Quantify the heating and cooling energy conservation potential of alternative landscape designs for a range of Minnesota building types and climatic regions using computer building energy simulation models. Translate these results into useful planting guidelines for both individual properties and for community scale programs, for use by the public and for evaluating cost-share projects.

2. Procedures:

(a) The DOE2E computer model for assessing energy use in structures will be adapted to use in assessing various building-planting schemes for their energy-conservation potentials under a range of Minnesota climatic conditions. The DOE2E computer program is considered the most advanced building energy simulation model, which is widely used by building researchers nationally and abroad. The methodologies developed by Lawrence Berkeley Laboratory using DOE2E for modelling tree-planting energy-conservation potential (including direct shading, peak loads, heat island and wind effects) will be assessed for adaptation and use in this project. Set-up of the DOE2E computer system will be done with Cold Climate Housing Center (CHCC) and Minnesota Building Research Center (MnBRC) staff with guidance from Underground Space Center (USC) staff currently using DOE2E.

(b) The physical and energy-use characteristics of a range of specific home and small public/commercial building types representative of those existing in Minnesota will be compiled and translated into prototype buildings to be tested with information developed by CCHC, MnBRC, and USC. Building parameters to be quantified include structure size, form, materials, insulation, ventilation, and fenestration (windows and doors).

(c) A better data base will be generated on critical physical and growth characteristics of plants. Data on measurements of trees and shrubs in community settings in various locations across Minnesota will be gathered to better determine typical size, form, growth rate, and foliation periods of Minnesota plants. Measurements made in other states of wind reduction and shading characteristics of plants (transmissivity) will be compiled and adapted for Minnesota trees.

(d) Aerial photographs of a sample of Minnesota communities will be interpreted to determine existing and potential tree cover. This tree cover data will be critical in determining the impact of community forests on wind and heat island reduction.

(e) A thorough assessment will be done of research conducted elsewhere on the effects of vegetation and urban conditions on local climate with particular attention to the impacts of vegetation on wind and urban heat island. The applicability of this information to Minnesota conditions and to energy conservation will be assessed. Methodologies of accurately modeling plantings' impacts on local heat island and wind conditions as well as human comfort in non-air-conditioned structures will be integrated, to the extent possible, into the computer modeling.

(f) A range of site plans using the test buildings and plants will be developed to represent alternatives with potential for energy conservation. Plans will be developed first for individual sites, then for clusters of buildings to simulate the effect that buildings and vegetation of adjoining properties have on each other. The plans of clusters will also be combined to simulate community scale situations.

(g) The alternative designs will be evaluated with the DOE2E program and compared to results obtained previously with the CALPAS3 program (see discussion of the CO2 project below in the "Context" section). Emphasis will be placed on testing new information on the impacts of plants on wind shielding and outdoor air temperature; and, their subsequent impact on energy use. Furthermore, the study will expand current knowledge on the impacts of tree shade.

(h) The model for assessing cost-effectiveness of alternative planting scenarios using net present values as in the "CO2 Project" will be further developed and applied to the alternative designs. Particular attention will be paid to assessing the benefits of community scale planting and tree preservation programs.

(i) The results of this research will be carefully analyzed to develop recommendations on the best energy conservation practices for individual properties and for communities typical of those across Minnesota.

(j) Illustrated planting guidelines will be prepared comparing advantageous and improper plantings for sites representing a range of conditions found in communities across Minnesota. These guidelines will become a basis for publications to be developed (Objective B) and will be used to provide training and to evaluate the projects proposed for cost-sharing (Objective C).

3. Budget:

		LCMR Funds
a.	Amount Budgeted:	$199,450
b.	Balance:	-0-

4. Timeline:

	7/91	1/92	7/92	1/93	7/93
Computer setup	**********				
Building definition	**********				
Tree data	**********				
Urban tree cover	**********				
Climate factors	**********				
Site plans		**********			
Computer runs		**********	**********		
Cost/benefit analysis				**********	
Analysis & recommendations				**********	
Guidelines				**********	

5. Status:

Because of delays in the approval of funding from the US Department of Energy, the University and the DNR contract to undertake this work was not fully completed until November 1991 with an operative start date of October 4, 1991. This has effectively delayed completion of the research by at least several months.

The following work has been completed for each Work Program Procedure listed above:

(a) The DOE2.1D computer model is now operational on a University of Minnesota computer system. Routines have been developed to simulate trees with reasonable input and output flexibility and for increased speed of simulations. The computer system can now simulate the shading impacts of evergreen and deciduous trees of four sizes either as individual trees, combinations of trees, or rows of trees at locations around the prototype buildings.

(b) A range of single-family home simulations (prototype building definition) have been developed and comprehensively tested. Specifically, fourteen house types have been developed with varying physical geometries, including 1-story or 2-story, square or rectangular, either north-south or east-west orientation, with even window distribution or clustered windows (e.g., garage). Each of these is being compared for three energy-efficient levels (considering various levels of airtightness, insulation, and mechanical system efficiency). Furthermore, the system has been developed to simulate energy use of selected buildings for three different site contexts (rural, suburban and urban) using weather data files for three midwestern cities (Mpls.-St. Paul, Fargo and Sioux Falls). Comparisons are being made between the simulated energy of these prototypes and comparable simulations done in other research projects.

(c) Measurements of selected species of trees of known age within the Metro Area have been completed and this data has been analyzed. The methodology and interpretation of the results are being written. The tree foliation period data was collected in both the Spring and Fall (1992). This data has been tabulated into a spread sheet program with the results being evaluated and compared to findings in the literature. Furthermore, a tree growth simulation model has been adapted for use with open grown landscape trees. The data files for selected Minnesota locations have been created with computer runs currently being finalized.

(d) A methodology for interpreting aerial photographs of community tree cover and integrating that with EPPL land use files was tested for areas in the City of Chanhassen. This methodology was found to be unacceptable because the State's GIS land use data is only available from 1984 and is too inaccurate for the scale needed for tree cover analysis using the proposed methodology. General recommendations are being developed on whether future research could use Landsat imagery to evaluate tree cover for various land use categories.

(e) Assessment of the relevant climate information has indicated that heat island modification has limited potential for Minnesota communities. Information correlating tree cover to wind impacts was used for prototype site plans and computer simulations.

(f) Computer shading simulations of individual prototype homes and trees have been completed. The results were used in developing recommendations on tree placement and tree species selection to be used in the publications.

(g) Simulations on the impact of tree shade on building energy use for various tree and building combinations have been completed. Approximations of potential savings due to wind reductions and for some additional combinations of trees and buildings are currently being completed.

(h) The methodology to conduct the cost-benefit analysis on the energy simulation results has been adapted from that used in the previous research (CO2 study). Cost-benefit analysis has been completed for effects of tree shade on building energy use. Final analyses will be completed as additional simulations are finished.

(i) The results of the above work are being analyzed as they are completed and a series of technical papers are being prepared for submission to the LCMR and to appropriate technical journals for possible publication. Recommendations on basic strategies for plantings as well as species selection and location have been included in the publications.

(j) Illustrations based upon the computer-generated shading study perspectives have been developed for the various prototypical plans. Plan drawings were completed for selected projects (including neighborhoods and non-residential uses) from the community cost-share program. Narratives are being completed to describe each prototype plan and case study.

6. Benefits:

This phase of the project will expand the information necessary to most effectively plant for Minnesota's unique combined needs for reducing both air-conditioning demand and winter heating costs. To satisfy the varied needs of people through Minnesota, alternative designs will be evaluated and planting guidelines will be developed for each region's different climate, community environments, buildings, vegetation, and energy consumption patterns. This phase of the project will lead directly to improved quality of both of the subsequent phases. Evaluations of cost-effectiveness of alternative plantings are also of interest to Minnesota utilities and will indicate whether to incorporate energy-conservation plantings into the utilities' Conservation Improvement Programs.

B. **Publish and distribute information to the public to encourage effective energy conservation plantings.**

1. Narrative:

Use research from Objective A to prepare and distribute information to residential, small business and community target audiences throughout the state to encourage and guide widespread cost-effective plantings to reduce energy consumption.

2. Procedures:

Work closely with research staff developing guidelines to obtain specific planting recommendations and information necessary to write, produce and edit brochures for the following audiences:

(a) Residential audience to be distributed via the DPS Energy Information Center, Minnesota Extension Service, and Cold Climate Housing Information Center.

(b) Small business audience to be distributed through the Energy Information Center and other established networks such as Minnesota Extension Service, Department of Trade and Economic Development, and Tourism office.

(c) Communities undertaking tree planting programs to be distributed through the community energy council program and the above named networks as well as the DNR and Department of Agriculture.

3. Budget:

		LCMR Funds
a.	Amount Budgeted:	$31,300
b.	Balance:	-0-

4. Timeline:

	7/91	1/92	7/92	1/93	7/93
Coordinate with research staff	**********				
Development of brochures		**********			
Complete brochures and distribution			**********		

5. Status:

Two publications have been produced. The first publication entitled "Energy-Saving Landscapes: The Minnesota Homeowner's Guide" was produced in conjunction with the DNR, the University and the Department of Public Service. 50,000 copies of this ten-page, two-color brochure were printed and distributed statewide this Spring primarily to Minnesota ReLeaf grant recipients (communities and organizations) as well as the nursery industry, other state agencies and the general public. This publication was used as the primary information source (in conjunction with workshops) to ensure proper planting for energy conservation (strategic location of new trees).

The second brochure (30 pages, two-color) entitled, "Energy Conservation Through Community Forestry" is currently in final production and will be available mid-summer 1993. Because of budget cuts and personnel changes in the Department of Public Service, this agency's involvement in the development of the publications has been minimal (primarily assistance with editing) with a non-agency consultant providing much of the work on the second publication.

6. Benefits:

The series of publications to be developed will save public and private monies through wise investments and will improve the effectiveness of implementation of energy conservation programs. Homeowners, renters, small businesses and community organizations can use this information to plan and most effectively use plantings to reduce energy consumption in each region of the state.

C. **Provide cost-sharing for energy conservation plantings.**

1. Narrative:

As one part of the overall MINNESOTA ReLEAF Implementation Plan, this portion of the program will provide cost-sharing funds to communities that have demonstrated the ability to match funds from local sources (i.e., businesses, non-profit groups, etc.), and have a prepared plan for energy conservation planting. Proposals from communities will be evaluated against criteria established by a multi-agency organization technical review group. Some pilot/demonstration projects may be solicited and approved prior to final publication of the brochures, but consistent with the on-going research findings. Furthermore, with the limited funding being requested, cost-sharing might initially be limited to only the purchase of tree and shrub planting stock.

2. Procedures:

A multi-agency work group will be established to develop appropriate practices and evaluation criteria. The program will be advertised to communities and planting proposals solicited. Training materials will be developed along with statewide training sessions as necessary. Following project selection by the work group, funds will be allocated and the communities will complete their projects. Work will be monitored by agency staff to insure proper compliance.

3. Budget:

	LCMR Funds	Matching Funds
a. Amount Budgeted:	$959,250	$959,250
b. Balance:	-0-	$900,000

4. Timeline:

	7/91	1/92	7/92	1/93	7/93	12/93
Establish work group	********					
Develop practices and criteria		**********				
Solicit proposals			**********			
Review proposals/Allocate funds				**********		
Complete planting projects					**********	

5. Completion of the second round of grant funding for the Metro Region was completed in February. Statewide, 125 project were approved and approximately 90% of these have been completed. Weather conditions (rain, rain and more rain) have delayed the implementation and completion of some 10-15 projects mostly in the southern region of the State. In addition, several non-profit organizations (e.g., in St. Paul, the West Side Citizen's Organization) have requested additional time to complete their projects primarily due to the need to promote and process their project applications (tree planting on private property).

All funds have been granted to the project sponsoring community or organization. Project extensions can be approved administratively without additional grant processing (e.g, a letter authorizing an extension can be sent to those grant recipients requesting additional time to complete their projects). Extensions are proposed for one more planting season (projects to be completed by October 31, 1993). These extensions will only be granted after the Division receives approval from LCMR.

D. **Implementation of MINNESOTA ReLEAF Program.**

1. Narrative:

This portion of the program is to establish the MINNESOTA ReLEAF program within the Department of Natural Resources to encourage, promote and fund the planting, maintenance and improvement of trees in Minnesota to reduce atmospheric carbon dioxide levels and promote energy conservation.

2. Procedures:

The implementation plan for the MINNESOTA ReLEAF program will be developed in cooperation with the Department of Natural Resources, Pollution Control Agency and other affected parties (i.e., MINNESOTA ReLEAF Committee). The implementation plan will contain the following elements:

(a) primary and secondary criteria for selecting projects for funding; and,

(b) recommended procedures for processing grant applications and allocating funds.

The primary criteria will include (but are not limited to):

(a) reduction and mitigation of adverse environmental impacts of atmospheric carbon dioxide; and,
(b) promotion of energy conservation.

Secondary criteria will include (but are not limited to):

(a) balancing of urban and rural needs;
(b) preservation of existing trees in urban areas;
(c) promotion of biodiversity, including development of disease-resistant and drought-resistant tree species;
(d) erosion control;
(e) enhancement of wildlife habitat;
(f) encouragement of cost-sharing with public and private entities;
(g) enhancement of recreational opportunities in urban and rural areas;
(h) coordination with existing state and federal programs;
(i) acceleration of the planting of harvestable timber;
(j) creation of employment opportunities for disadvantaged youth; and,
(k) maximization of the use of volunteers.

In addition, the Pollution Control Agency, in consultation with potentially affected parties will prepare implementation recommendations for applying a fee on carbon dioxide emissions for the program. The analysis will include the following:

(a) a review of the carbon dioxide sources and proposed fee base identified in the "CO2 Study";
(b) recommendations regarding exemptions, if any, that should be granted;
(c) a recommended method for measuring the amount of carbon dioxide emitted by various sources;
(d) a recommended procedure for administering and collecting the fees from the various sources;
(e) an estimate of the revenue that would be generated by the fees.

3. Budget:

		LCMR Funds
a.	Amount Budgeted:	$60,000
b.	Balance:	-0-

4. Timeline:

	7/91	1/92	7/92	1/93
Establish Committee	****			
Develop fee recommendations	*****			
Develop implementation plan	**********			
Implement program			**********	

5. Status:

The MINNESOTA ReLEAF Implementation Plan has been completed using input from both the MINNESOTA ReLEAF Advisory Committee and the multi-agency work group. As part of the Implementation Plan, the PCA has completed its Report entitled, "Carbon Fees to Support Minnesota ReLeaf: Implementation Recommendations", and has submitted the Report to the DNR. Both Reports have been approved by the LCMR.

6. Benefits:

The MINNESOTA ReLEAF program will act as an "umbrella" to help coordinate all tree planting efforts in Minnesota. Accomplishment tracking will be improved through the program. Multi-agency and citizen participation will ensure the widest range of input regarding criteria development and grant allocation procedures. Furthermore, establishment of a permanent fee structure for carbon dioxide emissions will help ensure long-term funding of statewide tree planting efforts.

IV. Evaluation

The methods used to simulate the impacts of trees on building energy conservation and the resulting quantifying of benefits and costs will be compared with results derived from previous work using other computer models, similar work from other regions of the country (including other DOE2E simulations), and with other methods for reducing building energy consumption applied by local utilities. Experienced researchers in this field (including Gordon Heisler with the USDA Northeastern Forest Experiment Station, Hashem Akbari at Lawrence Berkeley Laboratory, E. Gregory McPherson at the University of Arizona) will be asked to review the research methods and results. Once verified, the guidelines derived from this project's research will be used to evaluate the expected benefits and costs of community energy conservation planting proposals submitted for cost-sharing.

Additionally, the evaluation will include the results of the community planting projects (numbers of trees/shrubs planted, number of communities involved, number of volunteer hours donated) as well as the number of publications produced and distributed (by audience type). Effectiveness of the publications may be determined by including a short survey to be returned by the user/reader.

V. Context

A. Previously, research has not been conducted in Minnesota to quantify the impacts of vegetation on both air-conditioning and heating use. Studies done outside the state including those based on DOE2E simulations offer good methodologies for evaluating some aspects of energy conservation plantings. But, they have typically focused on southern U.S. sites or only the cooling half of energy loads, and thus have limited direct applicability in guiding planting specifically for Minnesota.

The 1990 Minnesota Legislature in cooperation with Northern States Power and Minnesota Power and Light are supporting a current project to quantify the benefits and costs of planting trees to mitigate the buildup of atmospheric CO2. One component of the "CO2 Project" used computer energy simulation program CALPAS3 to evaluate the energy savings derived from direct shading of a prototype residence by several simple combinations of trees. The "CO2 Project" and research being conducted elsewhere suggest that critical additional work is needed on the impacts of plantings on peak loads, wind infiltration, heat island effect (mesoclimatic impacts of mass plantings) in order to more fully and accurately assess the energy conservation values of landscape plantings.

Therefore, this LCMR study will use more advanced computer technology, further integrate other research, and test more building-landscape combinations to more accurately and fully predict the value of energy-conservation plantings for a range of Minnesota settings.

B. This proposal complements $80,000 of other funding already committed to the DNR by the USDA Forest Service and Northern States Power Company for energy conservation plantings. Furthermore, the research guidelines, publications and technical assistance represent a specific public service not presently existing in Minnesota, which builds upon existing state community forestry and energy programs. This project will also aid the state in securing more federal monies currently proposed through the "America the Beautiful" program for tree planting.

C. Not applicable.

D. Not applicable.

VI. Qualifications

A. Program Manager:

Jonathan E. Stiegler
Urban Forestry Coordinator
Division of Forestry, Minnesota Department of Natural Resources

M.S. Urban Forestry/Landscape Horticulture, University of Minnesota, 1985

Currently employed as State Urban Forestry Coordinator with responsibilities in developing cost-share programs for energy conservation tree planting, municipal tree inventories and management plans, as well as other urban and community forestry issues including tree preservation/protection, increasing public awareness, and to provide technical assistance and training to communities, individuals and state staff. Mr. Stiegler has 14 years of experience as a City Forester for the Cities of Robbinsdale and Golden Valley and is currently pursuing his PhD in urban forestry/landscape architecture at the University of Minnesota with his interest in studying public attitudes and perceptions of the urban forest. His primary role will be as program coordinator and administration of the cost-share program.

B. Major Cooperators:

1. Margaret A. Sand
Research Project Manager, Dept. of Landscape Architecture
University of Minnesota
Registered Landscape Architect

MLA, University of Minnesota, 1991

A principal investigator on the 1990 CO2 project responsible for developing energy conservation planting plans. Author of the Energy Conservation chapter of the Minnesota's Community and Urban Forests: Opportunities and Recommendations (1990) Report to the Legislature by the Minnesota Shade Tree Advisory Committee. Fifteen years practicing and teaching landscape architecture, including responsibility for teaching planting for energy conservation since 1985. Ms. Sand's primary roles are to develop planting designs to be tested, to develop planting design guidelines, and to evaluate the potential energy-conservation effectiveness of community cost-sharing proposals.

2. Patrick H. Huelman
Assoc. Professor/Extension Specialist, Department of Forest Products
Coordinator, Cold Climate Housing Center, Minn. Extension Service
University of Minnesota

M.S. Architectural Studies, Iowa State University, 1988

A principal investigator in cooperation with the DNR on the 1990 CO2 project responsible for conducting computer analysis with CALPAS3 of energy conservation potential of proposed plantings. Expertise in residential construction materials and methods,energy conservation, and solar energy systems, with eleven years of experience in Iowa and Minnesota in energy design consultation and education. Mr. Huelman's primary roles are to develop and run computer building energy simulation models and to develop data on buildings to be tested.

3. Edward I. Sucoff
Professor, Department of Forest Resources
University of Minnesota

PhD. Plant Physiology, University of Maryland, 1960

Dr. Sucoff is a forest biologist with relevant expertise in tree characteristics, energy budgets of trees and forests, and carbon cycling. A principal investigator in the CO2 project determining the state carbon balance and the carbon-fixing potential of Minnesota trees. Dr. Sucoff's primary roles are to provide data on plant materials and their growth, to coordinate cost-benefit analyses, and to contribute to the quantifying of heat and heat island effects.

4. Donald G. Baker
Professor, Department of Soil Science,
University of Minnesota

PhD. Soil Science, University of Minnesota, 1958

Dr. Baker has worked as a meteorologist for more than forty-five years. His work has included both major reports on climatic conditions of Minnesota as well as the relationship of plant growth to climate. Dr. Baker's primary roles are to provide climatic data and assess the potential of reducing heat island temperatures.

5. David Grimsrud
Director, Minnesota Building Research Center
University of Minnesota

PhD. Physics, University of Minnesota, 1960

Dr. Grimsrud has extensive experience including sixteen years at Lawrence Berkeley Laboratory where he investigated energy processes and air quality in buildings. Specifically, a major portion of his work focused on the measurement and modelling of energy transfer in buildings, air infiltration and natural ventilation. Dr. Grimsrud's primary roles are to collaborate in modelling of wind factors and to evaluate validity of energy simulation and building models.

6. Chris A. Gilchrist
Information Program Supervisor
Minnesota Department of Public Service

Mr. Gilchrist is currently responsible for supervision of writing and production of public information for the Department. He has ten years of experience in this area specializing in providing energy conservation information to the general public. He has experience in supervising the Energy Information Center which answers 20,000 client inquiries and distributes 15,000 brochures annually. Mr. Gilchrist's primary role will be to supervise the development of energy conservation planting information (brochures).

VII. Reporting Requirements

Semiannual reports will be submitted not later than January 1, 1992, July 1, 1992, January 1, 1993 and a final status report by June 30, 1993.

TREE AND SHRUB PLANTING FOR ENERGY CONSERVATION IN MINNESOTA COMMUNITIES--ENERGY 3

Selected Publications List

Akbari, H., A.H. Rosenfeld, and H. Taha. 1990. Summer heat islands, urban trees, and white surfaces. ASHRAE Transactions. 96:1. (AT-90-24-1)

Baker, D., 1983. Climate of Minnesota. Part XIV. Wind Climatology and Wind Power. University of Minnesota Agricultural Experiment Station (AD-TB1955)

DeWalle, D.R. and G.M. Heisler. 1988. Use of windbreaks for home energy conservation. Agriculture, Ecosystems and Environment 22/23: 243-260.

Feustel, H., C. Zeurcher, R. Diamond, J. Dickinson, D. Grimsrud, and R. Lipschutz, 1985. Temperature and wind-induced air flow patterns in a stair case. Computer modelling and experimental verification. Energy and Buildings 8:105-122.

Greiner, T., P. Huelman, L. Hodges, M. Yearns, and K. Baker. 1987. The Home Heating Index. Housing and Society Journal.

Heisler, G.M. 1986b. Energy savings with trees. Journal of Arboriculture. 12:5:113-125.

Heisler, G.M. 1990a. Tree plantings that save energy. Make Our Cities Safe For Trees: Proceedings of the 4th Urban Forestry Conference. American Forestry Association pp. 58-62.

Huang, Y.J., H. Akbari, and H. Taha. 1990. The wind-shielding and shading effects of trees on residential heating and cooling requirements. ASHRAE Transactions 1990. 96:1 (Preprint copy AT-90-24-4).

Huang, Y.J., H. Akbari, H. Taha, and A.H. Rosenfeld. 1987. The potential of vegetation in reducing summer cooling loads in residential buildings. Lawrence Berkeley Laboratory. LBL-21291.

Huelman, P., L. Hodges, and J. Benson. 1983. Solar access protection: a new methodology and sample easement. Proceedings of the Annual Meeting of American Solar Energy Society.

McPherson, E.G., L.P. Herrington, and G.M. Heisler. 1988. Impacts of vegetation on residential heating and cooling. Energy and Buildings 12:41-51.

Mital, D. and E. Sucoff. 1983. Simulated water defects in Minnesota aspen stands, 1930-1975. Proceedings of the 7th National Forest Biology Workshop. Physiology and Genetics of Intensive Culture. University of Kentucky: 440-445.

Sherman, M., M. Modera, and D. Grimsrud. 1982. A predictive air infiltration model-field validation and sensitivity analysis. Proceedings of the Third International Symposium on Energy Conservation in the Built Environment, An Foras Forbatha, Dublin.

Sucoff, E. and C. Buschena. 1986. Six-year growth of trees and shrubs along Minnesota roads especially as affected by deicing salts. Minnesota Department of Transportation Research and Development Report. (Supplemental LRRB Investigation 636).

Winkler, J., R. Skaggs and D. Baker. 1981. Effect of temperature adjustments of the Minneapolis-St. Paul urban heat island. Journal of Applied Meteorology 20:1295-1300.