TECHNICAL POTENTIAL FOR SHADE TREE PLANTING IN SACRAMENTO COUNTY

Submitted to:

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Final Report

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CONTENTS

Executive Summary
- Key Findings....4
- Conclusions and Recommendations....7

Introduction
- Program Description....9
- Previous Research....11
- Research Objectives....11

Procedures
- Study Area....13
- Aerial Photograph Analysis....13
- Data Analysis....17
- Scenarios....20
- Limitations of the Study....24

Results and Discussion
- Characteristics of the Residential Units....26
- Scenarios....26
- Discussion....30

Acknowledgements....38

References....39

Appendices
- Appendix A - Tally Sheet....41
- Appendix B - Micropas Simulation Input and Output for Prototype Building....42
- Appendix C - Cost-Effectiveness Analysis Example....55
- Appendix D - Data for Existing Trees Scenario....56
- Appendix E - Data for Tree Planting Potential - All Sites Scenario....68
- Appendix F - Data for Tree Planting Potential - Sacramento Shade Scenario....79
- Appendix G - Data for Tree Planting Potential - Forest Service Scenario....81

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EXECUTIVE SUMMARY

The Sacramento Tree Foundation (STF) and Sacramento Municipal Utility District (SMUD) are partners in Sacramento Shade, an energy-efficiency program with the goal of planting 500,000 trees by the year 2000. Over 170,000 trees have been planted to date. The objective of the Sacramento Shade Program is to create a healthy urban forest that will provide shade and summer air-conditioning savings.

In 1994 Barakat & Chamberlin, Inc. completed a process evaluation of the Sacramento Shade Program. One recommendation was to conduct a study to quantify the remaining tree-planting potential in the SMUD service area. Knowledge of future tree planting potential could be used to determine if the goal of planting 500,000 trees is achievable and to more accurately establish and allocate resources to meet the program's long-term goals.

In October, 1994, STF contracted with the USDA Forest Service's Western Center for Urban Forest Research and Education to identify the number of energy-conserving planting sites in the SMUD service area. The study was designed to provide information beyond a count of tree sites. For example, because air conditioning savings are related to tree location, information regarding the distribution of tree sites with respect to building orientation can be indicative of potential savings. Also, information on the number of sites for trees of different sizes could help gauge the demand for different types of trees.

Using large-scale aerial photographs of residences within urbanized Sacramento County, we classified existing trees and potential tree planting sites by tree size, cardinal direction, and distance from buildings (to property line or 60-ft maximum distance, whichever is closer). A "10-ft Decision Rule" guided interpretation of future tree planting sites. The rule required selecting the largest trees possible (maximum is 60-ft crown spread) to fill the available space as long as trunk was a minimum of 10 ft from any building wall, paved or wood surface, and property line. Future tree sites had to be spaced so that future mature tree crowns did not come within 10 ft of existing or future tree crowns.

Our unbiased sample was designed to provide estimates for 61 of the County's 71 SubRegional Assessment Districts (SubRADS). The 61 SubRADs contained 98 percent of all residents in the County. The 2,921 sampled structures represented 0.84 percent of the 346,186 single family detached buildings, 2-4 unit buildings, and mobile homes in the County as of January 1994.

We present information on tree sites for four scenarios: existing trees, tree planting potential - all sites within the 60-ft shading envelope, Sacramento Shade sites, and Forest Service sites. The last two scenarios are based on siting guidelines currently used by the Sacramento Shade program and

hypothetical guidelines developed by the Forest Service using computer modeling of air conditioning savings from tree shade and cost-effectiveness analysis.

In our results we present unadjusted counts of tree sites, as well adjusted totals that convert small and large tree sites to a common reference based on medium-sized trees. The adjusted totals allow for comparison of planting opportunities across scenarios by normalizing for tree size. We used an adjustment ratio of 0.75:1:3 for small (10-20 ft crown spread), medium (21-40 ft spread), and large (41-60 ft spread) tree sites, respectively. The sample mean and standard deviation of adjusted sites per residence were estimated for each SubRAD and the total number of adjusted sites were projected by multiplying the mean number of sites per structure times the total number of residential units in each SubRAD.

KEY FINDINGS

The distribution of tree sites around buildings is related to building orientation and lot layout. The most frequent front orientation of structures in our sample was south (23%), north (22%), west (17%), and east (16%). Only 24 percent of the structures had intercardinal orientations (i.e., northeast, southeast, southwest, northwest).

Existing Trees

There are approximately 872,287 trees (985,177 adjusted) located at all directions within the 60-ft shading envelope of residential units in our study area. The overall mean is 3 trees per residential unit and with 95 percent confidence the true mean is between 2.84 to 3.16. About 45 percent are medium-sized, 44 percent are small-sized, and 12 percent are large-sized trees. Most trees (64%) are opposite walls facing cardinal directions (i.e., north, south, east, west), with a relatively even distribution across directions. Similarly, remaining trees are distributed evenly across the intercardinal directions. Approximately 60 percent of existing trees are within 20 ft of the residential structure (i.e., adjacent), 29 percent are between 21 and 40 ft (i.e. near), and 10 percent are between 41 and 60 ft (i.e., far).

SubRADs with the greatest number of trees per residential unit occur in the City of Sacramento, north and northeast of Sacramento, Galt, and Rancho Murieta. SubRADs that ring the downtown area (e.g., Land Park, North Sacramento, East Sacramento) and that are northeast of Sacramento (e.g., Arden-Arcade, Carmichael) contain the greatest number of trees in absolute terms.

Tree Planting Potential - All Sites

The estimated number of potential tree planting sites is 678,371 (844,192 adjusted). The overall mean is 3.15 tree sites per unit, with 95 percent confidence the true mean is between 2.97 to 3.33. Most sites are for medium (44%) and small trees (39%). Sixty-six percent of the sites are

within 20 ft of the structures, 23 percent between 21 and 40 ft, and 11 percent between 41 and 60 ft. About two-thirds of the sites are opposite walls facing cardinal directions, with relatively more sites opposite south and north facing walls (18-21%) than west and east facing walls (13-15%). Slightly more tree sites are northeast and northwest (8-9%) than southeast and southwest (7%).

SubRADs with the most tree planting potential per residential unit are in areas such as Rio Linda-Elverta, Vineyard, Galt, Elk Grove, and Orangevale. These areas also have the greatest total number of potential planting sites. Generally, SubRADs with the least potential for future tree planting have the greatest number of existing trees per residential unit (downtown Sacramento, Meadowview and the Pocket, South Natomas, and Citrus Heights).

Tree Planting Potential - Sacramento Shade Guidelines

The Sacramento Shade siting guidelines do not permit planting north of buildings or at distances greater than 35 ft from building walls. These restrictions reduce the number of potential planting spaces by 30 percent, from 678,372 to 473,549. There are approximately 576,157 potential tree planting sites when the count is adjusted for tree size. The overall mean is 2.11 sites per residential unit and with 95 percent confidence the true mean ranges between 1.99 and 2.23. The distribution of potential sites by tree size class is similar to that for the All Sites scenario: 45 percent medium-sized trees, 40 percent small trees, and 16 percent large trees. Twenty-four percent of all tree sites are south of buildings, while 20 percent are opposite east walls and 18 percent are opposite west walls. Intercardinal sites are split nearly equally between east (19% northeast and southeast) and west (20% northwest and southwest) sides, but more tree sites are north (21% northeast and northwest) than south (17% southeast and southwest) of structures. Seventy-two percent of the potential tree sites are 10 to 20 ft from structures, while the remaining 28 percent are 21 to 40 ft away.

SubRADs with the greatest number of potential tree planting sites per residential unit generally occur in urbanizing areas along the State Route 50 corridor, south and east of Sacramento (e.g., Vineyard, Elk Grove, Franklin-Laguna, Galt), and to the north (North Natomas, Rio Linda-Elverta, Antelope). With some exceptions (e.g., North Natomas) these SubRADs have among the highest numbers of total tree planting sites. Land Park and Carmichael have low potential per unit but relatively large numbers of potential sites because they contain more residential units than many other suburban and rural SubRADS.

Tree Planting Potential - Forest Service Guidelines

Benefit-Cost Ratios (BCR) based on 72 shading simulations of air conditioning energy use provided the basis for Forest Service siting guidelines. The 1,700 ft^2 base case building met Title-24 energy efficiency standards and had window and wall areas evenly distributed among surfaces facing each cardinal direction. We found that the largest BCRs occur for trees located west of the

building, with values increasing with tree size and decreasing with distance from the building. Generally, the larger a tree is and the closer it is to the building, the more shade it provides. The large benefit from west shade compared to east shade is due to the relatively high avoided cost of capacity, which occurred from 1 to 8 p.m. on the building's peak cooling day (August 7).

Our simulation results suggest that small trees are only cost-effective on the west. Medium-sized trees are cost-effective at directions between east and northwest, but need to be located relatively close to the building unless placed directly east or west. There is more flexibility in siting large trees than smaller trees.

Assuming these restrictive guidelines, there are approximately 262,798 (395,163 adjusted) potential planting sites where trees were simulated to have BCRs of 0.5 or greater. We selected a BCR of 0.5 as the cutoff since trees with BCRs of 0.5 to 0.99 could be cost-effective assuming different building characteristics than were simulated for our base case (i.e., relatively large amounts of window area, short overhangs, no existing shade). About 70 percent of the total number of potential planting sites are ineligible for planting with this scenario. The overall mean is 1.5 sites per residential unit and with 95 percent confidence the true mean ranges between 1.36 and 1.64. More sites are available for medium (60%) and large (27%) trees than for small trees (13%). Seventy-five percent of all sites are opposite west (28%), south (24%), and east (24%) walls. Most of the remaining sites occur to the southwest (8%) and northwest (7%). Seventy-eight percent of the potential tree sites are adjacent to buildings, 18 percent are near, and 4 percent are far.

Tree planting potential varies slightly from the pattern for the Sacramento Shade scenario. SubRADs along the State Route 50 corridor and Antelope have less potential, perhaps because relatively smaller lots reduce the potential for larger-sized trees, which constitute more of the Forest Service sites than Sacramento Shade sites.

Limitations of the Study

The Forest Service guidelines are based on modeling energy consumption of a single building and related benefit-cost analysis. Although this approach is expedient, it oversimplifies the diversity of housing stock, occupant, and mechanical heating and cooling system characteristics in SMUD's service area. BCRs assumed 1994 avoided costs and program costs. These costs will be different in 1995 and beyond, resulting in different streams of projected benefits and costs than cited here. More importantly, the BCRs are very sensitive to tree mortality, something that we know very little about after initial establishment losses are accounted for. Also, the BCR's in this study do not explicity account for increased space heating costs associated with winter shade or the "indirect effect" of trees on air temperature and wind speed. Studies suggest that each of these factors can influence heating and cooling loads by 1 to 10 percent per tree. For these reasons, our BCRs are first order estimates that require further investigation before serving as a basis for program evaluation and development.

There is error and uncertainty associated with estimates of tree planting potential. Accurate aerial photo interpretation is one source of error. Planting constraints that were undetected by our interpreters are one way in which technical potential could be overestimated. Constraints include overhead power lines, decks and patios, drainage swales, underground utility lines, and existing small shrubs and trees that need space to grow (e.g., 112,000 trees were planted from 1991 through 1993 by the Shade Tree Program alone, and most were too small to be visible on the aerial photographs). Conversely, removal of trees since the photographs were taken and new home construction are unrecognized sources of increased technical potential. The magnitude of these errors could be detected by ground-truthing of sampling sites in the field.

Our estimates of potential planting sites are static because they are based on interpretation of aerial photos taken between 1989 and 1993. Conditions have changed since the aerial photographs were taken. Therefore, results are a single "snapshot" of the space resource for residential shade trees. Technical potential will continue to change as redevelopment and new construction influence oppportunities for new plantings and as the Sacramento Shade program evolves.

It is also important to recognize that this is a study of technical potential, space available for energy-efficient tree plantings, and not a study of market potential. Market potential will be less than technical potential because some customers will not want trees planted in certain locations. Trees may conflict with a resident's desire to preserve access to the backyard, preserve existing views, maintain an open landscape for security reasons, retain solar access to pools, solar collectors, and vegetable gardens, and maintain a litter-free landscape. Market potential will change as customers attitudes about the value and benefits of trees change. Survey research is needed to determine the percentage of potential planting sites residents are willing to plant. Information on reasons people choose not to plant trees may be useful in marketing the program. With a relatively small amount of additional support from STF and SMUD this research could be accomplished during summer 1995. Information from field work and a questionnaire could provide more accurate estimates of actual tree planting potential in Sacramento County.

CONCLUSIONS AND RECOMMENDATIONS

Assuming current Sacramento Shade siting guidelines there are approximately 473,549 potential tree planting sites in Sacramento County (576,157 adjusted). Seventy percent of these sites are located in directions from which the greatest air conditioning savings are usually obtained (i.e., east, south, southwest, and west). About two-thirds of the sites are within 20-ft of the buildings and 84 percent require small or medium-sized trees.

Results of our cost-effectiveness analysis indicate that Sacramento Shade's current policy of not siting trees north of buildings is sound. However, BCRs for medium and large trees sited 50-ft west of the prototype were greater than 1.0 and therefore cost-effective. We recommend that Sacramento Shade evaluate the siting guideline prohibiting planting beyond a distance of 35-ft from building walls. Permissible distances could be extended to the west and perhaps the east.

Guidelines for tree planting to the southeast, south, and southwest should emphasize medium and large trees located 10 to 30 ft from the house. Planting of small trees to the south is not likely to be cost-effective.

Adoption of more stringent siting guidelines, such as were developed for the Forest Service scenario, will reduce the number of potential sites for shade tree planting, but perhaps increase future air conditioning savings per tree. Although Sacramento Shade and Forest Service guidelines eliminate many planting sites, these eliminated sites provide substantial opportunity for tree planting that can produce air conditioning savings associated with lower summer temperatures and reduced wind speeds, as well as other environmental (e.g., air cleansing, rainfall runoff reduction, wildlife habitat), economic (e.g., increased property values), and aesthetic benefits.

While Sacramento Shade's current guidelines could be fine-tuned to better incorporate sun/tree/building geometry, we do not recommend adopting strict guidelines as exemplified in the Forest Service scenario. Ideally, siting guidelines provide the limits within which knowledgeable foresters assist residents site trees to maximize air conditioning savings. The forester needs to consider which trees are most suitable at each potential site, the likely impact of shade from trees at each site on the building air conditioning energy use, and the customer's needs with respect to compatibility of new trees with the overall landscape. Strict guidelines may hinder the ability of foresters to find satisfactory solutions. For example, in our experience air conditioning savings from tree shade are quite sensitive to the amount and orientation of window area. Trees planted northwest of a home with large amounts of northwest-facing window area may be very cost-effective, although the Forest Service guidelines indicate that this is seldom the case.

We recommend providing foresters with a shading envelope that establishes normal boundaries for cost-effective tree planting, and supplementing this with more specific training on strategic tree siting. Training might focus on identifying locations where trees are not likely to be cost-effective, as well as prioritizing remaining locations with respect to their savings potential. Such training might consist of classroom and field work covering topics such as: sun/building/tree geometry, solar heat gain in buildings, tree growth and mortality. By training foresters in cost-effective shade tree siting they will be better able to eliminate siting of ineffective trees and increase net benefits by strategically siting the remaining trees for maximum air conditioning savings. Staff of the Western Center for Urban Forest Research and Education are ready and willing to assist STF and SMUD with such an effort.

INTRODUCTION

The Sacramento Tree Foundation (STF) and Sacramento Municipal Utility District (SMUD) are partners in Sacramento Shade, an energy-efficiency program with the goal of planting 500,000 trees by the year 2000. Over 170,000 trees have been planted to date. The objective of the Sacramento Shade Program is to create a healthy urban forest that will provide shade and summer air-conditioning savings.

In 1994 Barakat & Chamberlin, Inc. completed a process evaluation of the Sacramento Shade Program (Peters *et al.* 1994). One recommendation was to conduct a study to quantify the remaining tree-planting potential in the SMUD service area. Knowledge of future tree planting potential could be used to determine if the goal of planting 500,000 trees is achievable and to more accurately establish and allocate resources to meet the program's long-term goals.

In October 1994, STF contracted with the USDA Forest Service's Western Center for Urban Forest Research and Education to identify the number of energy-conserving planting sites in the SMUD service area. The study was designed to provide information beyond a count of tree sites. For example, because air conditioning savings are related to tree location, information regarding the distribution of tree sites with respect to building orientation can be indicative of potential savings. Also, information on the number of sites for trees of different sizes could help gauge the demand for different types of trees.

The purpose of this report is to provide information on the characteristics and spatial distribution of potential tree sites as an aid for program planning. To this end we report results assuming current tree siting guidelines as well as for an alternative set of guidelines that we developed using computer modeling and analysis of cost-effectiveness. Our goal is to provide STF and SMUD with data to better understand relations between tree planting potential and tree siting guidelines.

We report results in three sections and Appendices. This section describes the Sacramento Shade Program, reviews a previous study, and outlines our research objectives.

PROGRAM DESCRIPTION

The Sacramento Municipal Utility District, in collaboration with the Sacramento Tree Foundation (STF), is implementing an innovative energy conservation program through the planting of 500,000 shade trees by the year 2000. The objective of Sacramento Shade, also referred to as the Shade Tree Program (STP), is to create an urban forest that will reduce the cooling needs of individual buildings by shading and mitigating the Urban Summer Heat Island (USHI) through air temperature reduction. The USHI is a climate modification caused by urban development which generates warmer air than the air in surrounding rural areas. Developed urban areas create heat islands in which daily temperatures are 5 to 10 degrees Fahrenheit higher than in surrounding rural environments, thereby increasing air conditioning loads.

Shade trees are an effective method for reducing air conditioning loads caused by direct sunlight as well as the indirect and adverse effects of USHI. Shade trees will directly reduce effects of USHI by providing direct shade for buildings, thereby lowering air conditioning loads (Akbari *et al.* 1993, Simpson and McPherson 1995). Also, through photosynthesis, trees sequester carbon dioxide in the air, and via the process of water evaporation (evapotranspiration) indirectly lower ambient air temperatures, thereby lowering air conditioning requirements (McPherson 1993, Simpson *et al.* 1995). This indirect effect of shade trees on energy use is, however, not included in SMUD's benefit-cost calculations for the Shade Tree Program because it has yet to be quantified with an acceptable amount of certainty (Sarkovich 1995).

The Shade Tree Program provides a comprehensive and long term program in planting, management, education and citizen participation which will result in measurable energy and capacity savings benefit, as well as the other environmental benefits that are difficult to quantify. The Shade Tree Program referrals are generated through SMUD and STF marketing which include various media advertisements, community presentations, the STF promotional field work (i.e. asking tree recipients to tell their neighbors), the STF publishing of articles and plantings schedules in local newspapers and the STF partnership with community based organizations. The referrals are collected through SMUD's centralized telephone system, and also by the STF staff and volunteers in the field. Once SMUD receives customers' requests for free trees, those requests are forwarded to the STF.

The STF community forester is expected to independently contact SMUD's customers and arrange site visits in order to mutually select appropriate tree species and to locate specific sites for each tree planting. In addition, the community forester organizes tree deliveries and tree planting demonstrations in certain centralized areas in customers' respective neighborhoods.

After receiving the delivery of the free 5 gallon trees (average of 4 trees per customer), the individual customer has the responsibility to plant those trees on the predetermined sites that will satisfy energy conservation specifications. In order to reach performance quotas of planted trees, each community forester recruits and trains volunteers who assist with the program.

Finally, the STF along with the volunteers provide "stewardship" of the planted trees for 3 years, about the time it takes for the trees to become fully established. The "stewardship" tree check-up is completed by mail after the first and third year and it is designed to collect information about the growth rate of the planted trees. If there is a problem of tree health, the customer is encouraged to call the 800 Shade Tree Hotline for advice.

Shade Tree Program goals and achievements include the following (Sarkovich 1995):

- The District and the STF have established an ambitious long term goal to plant 500,000 energy saving shade trees in the District service territory in the decade from 1990 to the year 2000. As of December 31, 1994 the program had planted approximately 166,500 trees.

- For 1994, the goal was to procure, plant, and steward at least 53,200 trees. As of December 31, 1994, the program planted 53,369 trees, at an average cost of $39 per tree.

- For 1995, the program goal is to procure, plant, and steward at least 55,800 trees.

- Broader and longer-term program objectives are to improve Sacramento's regional air quality, enhance the aesthetics and quality of life in the Sacramento area, and promote a sense of community spirit and cooperation.

Tree planting guidelines address tree orientation, distance to the building, and spacing between trees. Since its inception in 1990, the guidelines have evolved gradually. The original 1990 and subsequent annual contracts between the District and the STF have not contained any specific tree-siting guidelines. The first specific written tree-siting guidelines were established by the STF in 1991, and the guidelines were rather general: "Trees must be placed in a position to shade the house at some point during the day". In October of 1993, the tree-siting guidelines were revised by the STF to specifically state for the first time the maximum distance from buildings.

The current Shade Tree Program tree-siting guidelines are as follows (Sarkovich 1995):

- Trees may only be planted in west, east, or southern locations;

- Trees must be sited no farther than 35 ft from the house;

- Trees can not be sited where they interfere with power lines;

- Smaller trees must be sited a minimum of 8 ft away from the house, while larger trees must be 15 ft away from the house;

- Trees must be sited at least 6 ft from sidewalks, patios, driveways, or any other concrete surfaces; and

- Smaller trees must be spaced a minimum of 8 ft apart, larger trees must be 15 ft apart.

PREVIOUS RESEARCH

In 1992 Esther Kerkmann and Rowan Rowntree of the USDA Forest Service developed a preliminary estimate of potential sites for shade trees in Sacramento and Sacramento County (Kerkmann and Rowntree 1992). The study used random dot grid sampling of black and white aerial photography (1"=200') for the City of Sacramento to estimate tree canopy cover and Potential Energy-conserving Growing Space (PEGS). PEGS are untreed areas with grass or soil cover that are within 40 feet of east or west-facing walls and 20 feet of south-facing walls.

As a preliminary estimate, the study found that about 250,000 trees would need to be planted

during a 10-year period to fill all the PEGS. When applied to residential land, this translates into 2.4 trees per single family housing unit (87,854 units in 1990). This ratio was multiplied by the number of single family housing units in Sacramento County (248,488) to estimate a total tree planting potential of 586,371.

Several assumptions that could lead to erroneous estimates of tree planting potential are:

- Tree sites are estimated by dividing the total PEGS area by the area under a tree with a 35-ft crown spread. It is geometrically impossible for the estimated number of circular-shaped tree crowns to fit into this area without considerable crown overlap. This assumption is likely to overestimate tree sites.

- The study assumes that 20 percent of the existing tree cover dies during 10 years, thus creating an equal amount of space for new tree canopy. Estimating change in tree cover over time introduces a host of uncertainty: current age structure of the forest, expected life span of city trees, likelihood of 1 for 1 replacement.

- The study assumes that 30 percent of newly planted trees die during the 10-year period, requiring replacement trees. This figure is probably close to what might occur based on initial program findings.

- The average number of trees per residence projected for the County are assumed to be the same as for the City of Sacramento. Although we are not aware of studies that compare PEGS for city, suburban, and rural properties, related studies indicate that growing space increases along an urban-to-rural gradient as housing density decreases.

Although this study provided initial estimates of tree planting potential, a more comprehensive analysis was called for in the Process Evaluation report. In October 1994 the STF contracted with the USDA Forest Service's Western Center for Urban Forest Research and Education to conduct an extensive study of tree planting potential in the SMUD service area.

RESEARCH OBJECTIVES

The overall goal of this study is to develop information on the number, spatial distribution, and other pertinent characteristics of potential tree planting sites around residential units in the SMUD service area. Specific objectives are to:

1) Estimate the number of potential sites assuming current tree siting guidelines and a set of hypothetical guidelines based on a Forest Service analysis of cost-effectiveness.
2) Describe the planting potential for trees of different mature sizes.
3) Describe the distribution of sites at different directions around buildings.
4) Describe potential sites in terms of proximity to the residences.
5) Map the geographic distribution of sites within the SMUD service area.

PROCEDURES

Methods used to collect and analyze data are presented in this section.

STUDY AREA

The 995 square mile (258,000 hectare) study area is confined to the boundaries of Sacramento County, California. This area is divided into 25 Regional Assessment Districts (RAD, a census boundary-based planning unit used by the Sacramento Area Council of Governments). The RAD's are further divided into 1 to 7 smaller planning areas, SubRADs. There are 71 total SubRADs in the county that were used for aerial photo analysis.

AERIAL PHOTOGRAPH ANALYSIS

Two sets of black and white aerial photographs provide coverage of the urbanized portion of the county: 1993, 1:1,200 photographs from the city of Sacramento for SubRADs within the city limits; 1989 to 1993, 1:2,400 photographs from the county to cover most urbanized areas outside the city limits. Although 1:12,000, 9 x 9 inch prints were obtained for the entire county, their resolution was not sufficient to detect potential sites for individual trees. Therefore, our analysis was restricted to 61 SubRADs for which high resolution aerial photographs were available. Although our analysis missed 41 percent of area within the county, it included 98 percent of the population and 98 percent of all residential units in detached homes, 2 to 4 unit structures, and mobile homes. Information on each SubRAD's geography, demography, residential housing, and sample size is presented in Table 1.

Analysis of the sample residences within the study area was conducted using a systematic dot grid overlaid on the aerial photographs. Dot grid densities varied based on the size of each SubRAD such that at least 300 dots were classified in each SubRAD. Each dot falling on a 1 to 3 family residential unit was marked on the photo and every third dot was numbered and interpreted to identify characteristics of existing trees and potential tree planting sites. Limited resolution of the photographs made it difficult to accurately distinguish between structures containing 1 unit (i.e., detached single family) and structures with 2, 3 or 4 living units. Therefore, counts of existing and potential tree sites were recorded per sample structure rather than per residential dwelling unit.

Table 1. Information On Geography, Demography, and Residential Units by SubRAD.

SubRAD Number	RAD Name	Pop.	Acres	Pop/Acre	Total Units	Units Sampled	% Units Sampled
11	North Natomas	296	15,605	0.02	120	0	0.00
12	North Natomas	373	10,997	0.03	163	2	1.23
21	Rio Linda-Elverta	8,115	6,211	1.31	2,548	32	1.26
22	Rio Linda-Elverta	3,733	3,050	1.22	1,211	29	2.39
23	Rio Linda-Elverta	7,398	2,808	2.63	2,451	51	2.08
31	North Highlands-Foothill Farms	32,997	3,748	8.80	9,789	87	0.89
32	North Highlands-Foothill Farms	41,249	4,765	8.66	12,221	62	0.15
33	North Highlands-Foothill Farms	484	2,464	0.20	139	4	2.88
41	Citrus Heights	30,059	3,438	8.74	10,208	94	0.92
42	Citrus Heights	11,812	1,570	7.52	3,330	120	3.60
43	Citrus Heights	37,771	4,022	9.39	11,144	104	0.93
44	Citrus Heights	21,903	2,182	10.04	7,440	113	1.52
51	Orangevale	13,183	4,534	2.91	4,238	69	1.63
52	Orangevale	15,493	2,239	6.92	5,072	133	2.62
61	Folsom Area	10,081	2,345	4.30	3,022	48	1.59
62	Folsom Area	9,369	5,195	1.80	2,875	16	0.56
63	Folsom Area	20,400	7,798	2.62	4,702	25	0.53
71	South Natomas	678	4,512	0.15	327	3	0.92
72	South Natomas	38	2,705	0.01	21	0	0.00
73	South Natomas	33,013	3,864	8.54	8,565	41	0.48
74	South Natomas	3,580	1,260	2.84	286	1	0.35
81	North Sacramento	14,471	3,889	3.72	4,507	31	0.69
82	North Sacramento	33,999	4,696	7.24	10,313	57	0.55
83	North Sacramento	4,772	1,314	3.63	1,647	22	1.34
84	North Sacramento	6,253	1,844	3.39	1,193	11	0.92
91	Arden-Arcade	14,003	1,540	9.09	3,811	43	1.13
92	Arden-Arcade	24,188	2,835	8.53	7,087	88	1.24
93	Arden-Arcade	21,803	4,051	5.38	8,188	121	1.48
94	Arden-Arcade	35,415	4,185	8.46	9,193	52	0.57
100	Carmichael	49,851	6,960	7.16	15,622	69	0.44
111	Fair Oaks	8,303	1,783	4.66	2,487	53	2.13

SubRAD Number	RAD Name	Pop.	Acres	Pop/Acre	Total Units	Units Sampled	% Units Sampled
112	Fair Oaks	23,770	5,443	4.37	7,667	69	0.90
121	Rancho Cordova	34,301	3,746	9.16	10,060	75	0.75
122	Rancho Cordova	31,508	4,146	7.60	9,579	78	0.81
123	Rancho Cordova	21,462	11,779	1.82	6,893	24	0.35
124	Rancho Cordova	5,618	17,310	0.32	2,146	9	0.42
131	Downtown	1,624	1,545	1.05	319	4	1.25
132	Downtown	2,351	127	18.46	0	0	0.00
133	Downtown	4,007	408	9.82	715	13	1.82
134	Downtown	8,969	645	13.90	2,587	39	1.51
135	Downtown	9,206	670	13.73	2,278	34	1.49
136	Downtown	3,613	325	11.13	400	2	0.50
137	Downtown	4,458	521	8.56	1,341	29	2.16
141	Land Park-Pocket-Meadowview	34,394	4,383	7.85	13,150	56	0.43
142	Land Park-Pocket-Meadowview	9,675	1,740	5.56	3,135	78	2.49
143	Land Park-Pocket-Meadowview	19,225	2,112	9.10	5,956	63	1.06
144	Land Park-Pocket-Meadowview	28,152	3,109	9.06	8,574	75	0.87
145	Land Park-Pocket-Meadowview	23,366	4,946	4.72	5,919	33	0.56
151	East City	23,739	3,002	7.91	9,448	66	0.70
152	East City	11,168	3,571	3.13	3,206	19	0.59
153	East City	43,024	4,004	10.74	15,168	83	0.55
161	South Sacramento	34,185	3,353	10.20	9,579	58	0.61
162	South Sacramento	22,414	4,489	4.99	6,175	31	0.50
163	South Sacramento	43,441	5,561	7.81	14,426	72	0.50
164	South Sacramento	48,551	5,843	8.31	13,474	70	0.52
170	Vineyard	8,261	23,919	0.35	2,920	10	0.03
181	Franklin-Languna	24,855	5,921	4.20	7,979	42	0.53
182	Franklin-Languna	2,977	35,625	0.08	636	0	0.00
191	Elk Grove	3,041	3,773	0.81	960	26	2.71
192	Elk Grove	3,408	14,796	0.23	1,091	9	0.82
193	Elk Grove	19,465	3,053	6.38	6,015	51	0.85
200	Delta	5,717	104,537	0.05	2,305	0	0.00
211	Galt	12,431	4,805	2.59	3,802	32	0.84
212	Galt	3,209	1,971	1.63	1,118	19	1.70

SubRAD Number	RAD Name	Pop.	Acres	Pop/Acre	Total Units	Units Sampled	% Units Sampled
221	Cosumnes	22	6,144	0.000144	11	0	0.00
222	Cosumnes	423	39,287	0.01	114	0	0.00
223	Cosumnes	5,587	55,177	0.10	1,887	0	0.00
231	Southeast	495	16,063	0.03	165	0	0.00
232	Southeast	4,520	88,838	0.05	1,473	0	0.00
240	Rancho Murieta	3,254	7,859	0.41	1,325	8	0.60
250	Antelope	25,431	4,122	6.17	8,270	63	0.76
Totals		1,130,400	637,077	1.77	346,186	2,921	0.84

Information collected for each residence is shown in Appendix A. General information regarding lot and building characteristics was collected for subsequent building energy performance analysis. A clear plastic template was used to determine orientation of the front of the building. A second template was laid on the photo to determine the cardinal direction (8 possible direction classes), distance from building wall (3 distance classes), and crown diameter class (3 size classes) of existing and future trees (Table 2). Direction, distance, and size classes were developed with assistance from SMUD and STF to conform to Sacramento Shade siting guidelines. To confine the analysis to trees on-site and likely to shade the building, only trees/sites on the subject property and a maximum of 60-ft from the house were examined. Hence, our interpretation was confined to a "shading envelope" extending from each building wall to the property line or 60 ft, whichever was closer. A "10-ft Decision Rule" guided interpretation of future tree planting sites. The rule required selecting the largest trees possible (maximum is 60-ft crown spread) to fill the available space as long as trunk was a minimum of 10 ft from any building wall, paved or wood surface, and property line. Future tree sites had to be spaced so that future mature tree crowns did not come within 10 ft of existing or future tree crowns. Future sites were located as close to the building as possible without breaking the 10 ft decision rule. Four interpreters were trained in interpretation procedures and their work was periodically spot checked for accuracy and consistency.

Table 2. Information Collected From Aerial Photographs for Existing Trees and Potential Tree Sites

Category	Description
Tree Size	(crown diameter)
small	10-20 ft
medium	21-40 ft
large	> 40 ft
Distance from Opposite Wall	(distance to tree trunk)
adjacent	10-20 ft
near	21-40 ft
far	41-60 ft
Direction	(degrees azimuth)
north	337.6-22.5
northeast	22.6-67.5
east	67.6-112.5
southeast	112.6-157.5
south	157.6-202.5
southwest	202.6-247.5
west	247.6-292.5
northwest	292.6-337.5

DATA ANALYSIS

To compare the number of tree planting sites for different siting scenarios we first adjusted for tree size. This adjustment was necessary to normalize for the amount of space occupied by small, medium, and large-sized trees. For example, the space required to plant a few large trees could accommodate many more small trees. Our adjustment references small (10-20 ft crown diameter) and large (>40-ft crown diameter) tree sites to medium-sized (21-40 ft crown diameter) tree sites at each structure assuming trees are planted in a line parallel to the wall they shade with slight crown overlap, as per program siting guidelines (Figure 1). The resulting adjustment ratio is 0.75:1:3 for small (STS), medium (MTS), and large tree sites (LTS), respectively. The number of potential planting sites adjusted to the medium-sized tree (ATS_i) were calculated for each sample

residential structure as

$$ATS_i=(STS_i\times 0.75)+(MTS_i\times 1.0)+(LTS_i\times 3.0)$$

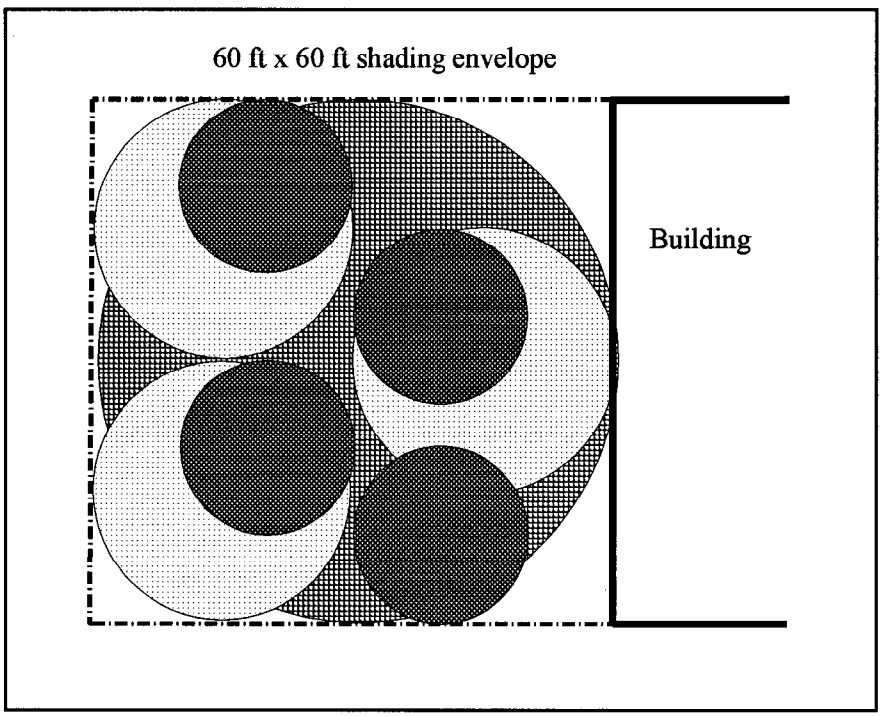


Figure 1. Example of assumed equivalency among one large tree (60-ft crown spread), three medium trees (30-ft), and four small trees (20-ft) used to calculate adjusted planting sites.

The sample mean (MAT_r) and standard deviation (SD_r) of adjusted sites were calculated for each $SubRAD_r$:

$$MAT_r=\frac{\sum_{i=1}^{n_r} ATS_i}{n_r}$$

where MAT_r is the sample mean number of sites adjusted for tree size for $SubRAD_r$, n_r is the number of residential structures sampled in $SubRAD_r$, and

$$SD_r = \sqrt{\frac{\sum_{i=1}^{n_r} (ATS_i - MAT_r)^2}{n_r - 1}}$$

The total number of adjusted planting sites in each SubRAD were projected as

$$PAT_r = MAT_r \times PR_r$$

where PAT_r is the projected number of sites in $SubRAD_r$ adjusted for tree size and PR_r is the total number of residential structures in $SubRAD_r$.

We used the Sacramento Area Council of Governments 1994 Housing Module (SACOG 1995) to define the population of residential units and obtain a current inventory of units by SubRAD. SACOG updates their inventory annually with building permit completion data. Our population includes single family detached buildings (1 unit per building), buildings with 2 to 4 housing units, and mobile homes. These types of residential buildings generally have 3 or more exterior walls that can be shaded by trees.

As of January 1994 the population of residential units in Sacramento County is 346,186 (SACOG 1995). Eighty-three percent (287,551) are 1-unit residences (i.e., single family detached), 12.6 percent (43,608) are 2 to 4 unit residences, and 4.3 percent (15,027) are mobile homes.

We sampled potential tree sites per structure, but housing data are in terms of residential units. Because the sample includes structures with 2 to 4 units, our projections are likely to overestimate potential sites by about 3 percent. For example, assume 5 potential tree sites for a 2-unit structure, or 2.5 trees per unit. Since our projections are based on the number of residential units, we project 10 total sites (5/structure x 2 units) when in fact there are 5 total sites (2.5/unit x 2 units). To estimate how this overprojection might influence our estimates of total planting potential consider that 13 percent (43,608 units) of our sample are buildings with 2 to 4 units, the number of units in the 2 to 4 unit category are split equally between 2-unit structures and 3 to 4 unit structures (based on housing data from the 1990 Census for Sacramento County), and the number of 3 and 4 unit structures are equal. This breakdown results in 17,262 structures (2-unit = 10,902, 3-unit = 3,634, 4-unit = 2,726). Assuming 1 tree site per structure (17,262 sites) and our projection is 1 site per unit (43,608), the overestimate is 26,346 sites (3% with 850,000 sites).

Several factors work to reduce this overestimate. First, our estimates of potential tree sites are likely to be less for multi-unit structures than for detached structures because common walls reduce opportunities for tree sites relative to structures with 4 exterior walls. Second, limited research suggests that as residential densities increase the relative amount of greenspace decreases. Finally, the number of multi-unit structures is a small percentage of the target population. Therefore, we believe that the net effect of this discrepancy is likely to be on the order

of 3 percent.

The overall (unweighted) mean (M) number of planting sites per residential unit was estimated as the average of the SubRAD means. M and the standard error (SE) of the sample were estimated as

$$M = \frac{\sum_{r=1}^{N} MAT_r}{N}$$

and

$$SE(M) = \frac{1}{N}\sqrt{\sum_{r=1}^{N} \frac{SD_r^2}{n_r}}$$

where n_r is the number of residential units sampled in $SubRAD_r$ and N is the total number of SubRADs.

SCENARIOS

Four scenarios were developed to describe existing trees and potential planting sites.

Existing Trees

Data concerning the numbers, locations, and sizes of existing trees were tabulated using the same analytical techniques as applied to potential sites. Of particular interest are relations between existing tree numbers, lot and building sizes, and potential tree sites across the SMUD service area. For instance, areas with many existing mature trees may have potential for future tree planting as old trees die and are replaced, but this may not be evident from the aerial photo data.

Tree Planting Potential - All Sites

Information on potential tree planting sites at all locations around target buildings are presented as baseline data. With these data we estimate the number of sites that will be lost as siting guidelines become progressively restrictive.

Tree Planting Potential - Sacramento Shade Guidelines

Data presented for this scenario assume no sites exist to the north. Also, sites greater than 40-ft from the buildings (the "far" distance) are excluded for all directions. Information on the number and locations of these sites are presented by SubRAD.

Tree Planting Potential - Forest Service Guidelines

Forest Service guidelines were developed based on cost-effectiveness analysis. The intent was to identify locations around a typical residence where mature shade trees of various sizes are cost-effective given current program costs and SMUD's anticipated future costs for energy and capacity. These sites were identified, counted, and characterized. The analysis consisted of three steps: shading simulation, building energy simulation, and cost-effectiveness evaluation.

Shading Simulations

We used the Shadow Pattern Simulator (SPS) (McPherson *et al.* 1985) to estimate hourly irradiance reductions on a prototype building for the 21st day of each month. Small, medium, and large trees were located at distances of 15, 30, and 50 feet opposite the square building's four walls and corners (Figure 2). 72 shading simulations were conducted (3 tree sizes x 8 directions x 3 distances). The simulated tree positions and sizes correspond with the scheme used to categorize tree planting potential from the aerial photographs (Table 2).

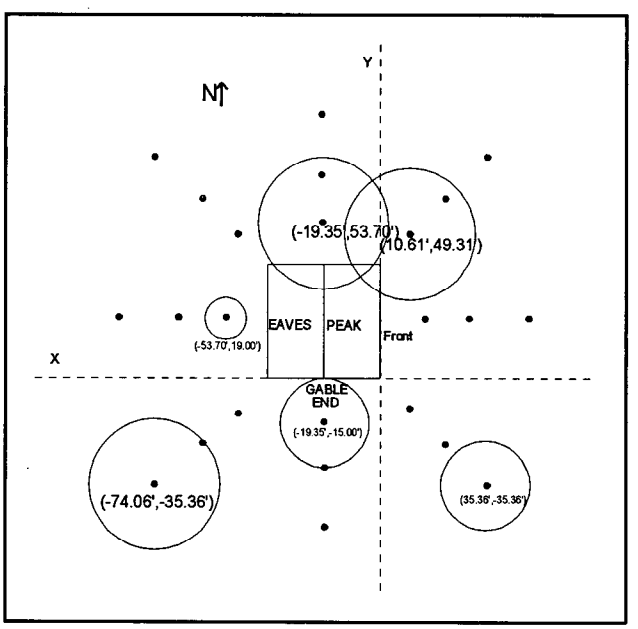


Figure 2. Tree locations and crown diameters relative to the prototype building used in the SPS simulations.

All trees in the 72 shading scenarios were simulated as ellipsoids with a distance of 7-ft from ground to canopy bottom. Tree heights and spread were, respectively: 17-ft and 15-ft for small, 35-ft and 30-ft for medium, and 52-ft and 45-ft for large trees. Trees were assumed to be in-leaf from April through November obstructing 82.5 percent of available irradiance. Trees were simulated to obstruct 30 percent of available irradiance during the December through March leaf-off season. Tree dimensions, crown densities, and foliation periods were obtained from local field measurements and the literature for species commonly planted by Sacramento Shade (McPherson 1984). Tree growth rates were based on measured data for street trees. These growth rates are likely to be conservative. Site conditions are usually more conducive to vigorous growth in residential yards versus streets. Also, the Sacramento Tree Foundation's stewardship activities are likely to result in healthier trees and more rapid growth compared to most of the street trees we measured.

Building Energy Simulations

We used a commercially available building energy analysis program, Micropas 4.01 (Enercomp 1992), to simulate impacts of tree shade on hourly air conditioning loads for the prototype building. Micropas accepts SPS results to reduce irradiance on building surfaces resulting from tree shade. Our one story, 1,700 sq ft prototype building was designed to meet Title-24 energy efficiency standards and have an annual air conditioning load similar to that of a typical single family residence in the SMUD service area (1,145 kWh) (SMUD 1994). Each wall was 41-ft long and contained 64 sq ft of window area to minimize confounding effects of building orientation. Insulation in the wood frame walls was R-11 and attic insulation was R-30. The seasonal energy efficiency rating of the air conditioner was 10. We assumed that shade from existing buildings and vegetation reduced solar heat gain through windows by 67.5 percent before incorporating SPS results. Appendix B contains additional information on Micropas modeling assumptions and the prototype building. Seventy-three Micropas simulations were run, one for each of the 72 SPS shading scenarios and one for the prototype without tree shade. Annual energy (kWh) and capacity (kW) savings were calculated as the difference between simulations with and without tree shade. Impacts of shade from trees on space heating were not considered.

Peak capacity was calculated as the average hourly air conditioning consumption during the 8-hour period from 1 p.m. to 8 p.m. on August 7, the day when the greatest hourly demand occurred. This average value for our prototype building was 2.14 kW, 19 percent greater than the SMUD-defined target of 1.80 (SMUD 1994). To meet the 1.80 target, all capacity values were divided by 1.19.

Cost-Effectiveness Evaluation

To evaluate cost-effectiveness we calculated a benefit-cost ratio (BCR) for each of the 72 shading scenarios. Each 30-year analysis assumed 100 trees were planted in 1995 at the same location with respect to 100 prototype buildings. Each "typical" 5-gallon tree was assumed to be 5-ft tall

and cost $39 to plant. This price is the current program's cost and includes costs of the tree, stakes and other planting materials, program administration, overhead, and 3 years of follow-up care and public education.

Because savings simulated with Micropas assumed a mature 30-year old tree, annual energy and capacity savings for years 1 to 29 were back-calculated from year 30 simulation results using an S-shaped curve. This curve distributes the savings over time in a manner that is consistent with a healthy tree's pattern of growth: slow at first, most rapid during the middle years, and slowing as the tree nears mature size. Small trees (10-20 ft tall) were assumed to reach mature size and produce maximum air conditioning savings 20 years after planting. Savings remained at this maximum level during years 21 to 30. We assumed that maximum savings were reached at years 25 and 30 for medium (21-40 ft tall) and large (>40 ft tall) trees, respectively (Figure 3).

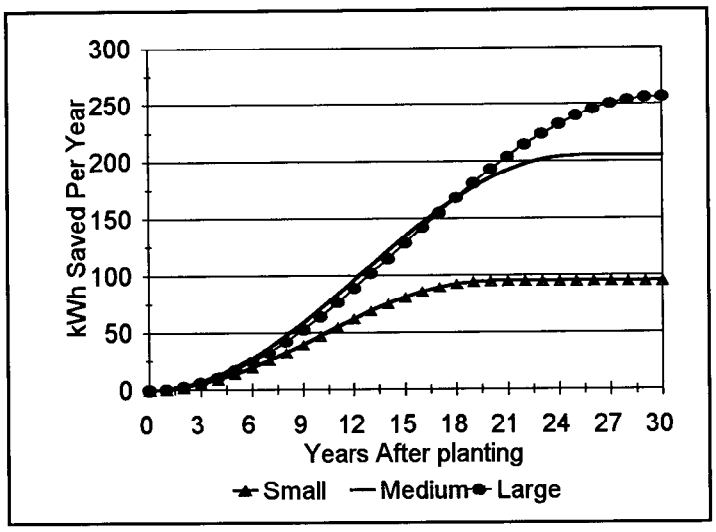


Figure 3. Annual air conditioning savings simulated for small (17-ft tall), medium (35-ft tall), and large (52-ft tall) trees located 15-ft from the west wall of the prototype building.

Annual energy and capacity savings were adjusted to account for tree mortality. Based on initial measures of Sacramento Shade's tree loss rates we assumed that 10 percent of the 100 trees planted would die during year 1 and year 2, when establishment-related losses are normally greatest. We assumed an annual loss rate of 5 percent for years 3 to 5, since it can take as long as 5 years for trees to become fully established. The annual loss rate was reduced to 1 percent for years 6 to 10 and to 0.5 percent for years 11 to 20. During this period trees are normally large enough to resist physical damage and vigorous enough to overcome most pests, disease, and other types of injury. We increased the annual loss rate to 1.5 percent during years 21 to 30 because growth is slowing and trees are often less resilient during their later years. Research is needed to confirm the accuracy of these projections. Given these assumed mortality rates, 69 of

the 100 trees planted were projected to survive to year 5, 66 to year 10, 63 to year 20, and 54 to year 30.

Total adjusted annual energy and capacity savings were calculated by multiplying the number of live trees times the per tree savings that were back-calculated from year 30. SMUD's nominal avoided costs for energy and capacity were used to translate total electricity savings into dollar savings. Nominal avoided costs for energy and capacity ranged from $0.0311/ kWh and $15.27/kW in 1995 to $0.1116/kWh and $237.73/kW in 2024 (personal communication, Misha Sarkovich, SMUD Monitoring and Evaluation, February 28, 1995).

The present value of benefits and costs were calculated for the 30-year period using a 5.9 percent discount rate, SMUD's cost of capital. A BCR was computed for each of the 72 shading scenarios by dividing the present value of benefits by the present value of costs. Scenarios with BCRs of 1.0 or greater were deemed cost-effective. Scenarios with BCR's from 0.50 to 0.99 are not cost-effective, but could be cost-effective if air conditioning savings associated with lower air temperatures are considered or building characteristics are different than those of the base case (i.e., relatively large amounts of window area, short overhangs, no existing shade). Therefore, trees at these locations are deemed marginally cost-effective. Those with BCRs less than 0.50 are considered not cost-effective. Appendix C contains a table that shows the cost-effectiveness analysis for one shading scenario.

LIMITATIONS OF THE STUDY

The Forest Service guidelines are based on modeling energy consumption of a single building and related benefit-cost analysis. Although this approach is expedient, it oversimplifies the diversity of housing stock, occupant, and mechanical heating and cooling system characteristics in SMUD's service area. BCRs assumed 1994 avoided costs and program costs. These costs will be different in 1995 and beyond, resulting in different streams of projected benefits and costs than cited here. More importantly, the BCRs are very sensitive to tree mortality, something that we know very little about after initial establishment losses are accounted for. Also, the BCR's in this study do not explicity account for increased space heating costs associated with winter shade or the "indirect effect" of trees on air temperature and wind speed. Studies suggest that each of these factors can influence heating and cooling loads by 1 to 10 percent per tree. For these reasons, our BCRs are first order estimates that require further investigation before serving as a basis for program evaluation and development.

There is error and uncertainty associated with estimates of tree planting potential. Accurate aerial photo interpretation is one source of error. Planting constraints that were undetected by our interpreters are one way in which technical potential could be overestimated. Constraints include overhead power lines, decks and patios, drainage swales, underground utility lines, and existing small shrubs and trees that need space to grow (e.g., 112,000 trees were planted from 1991 through 1993 by the Shade Tree Program alone, and most were too small to be visible on the aerial photographs). Conversely, removal of trees since the photographs were taken and new

home construction are unrecognized sources of increased technical potential. The magnitude of these errors could be detected by ground-truthing of sites in the field.

Our estimates of potential planting sites are static because they are based on interpretation of aerial photos taken between 1989 and 1993. Conditions have changed since the aerial photographs were taken. Therefore, results are a single "snapshot" of the space resource for residential shade trees. Technical potential will continue to change as redevelopment and new construction influence oppportunities for new plantings and as the Sacramento Shade program evolves.

It is also important to recognize that this is a study of technical potential, space available for energy-efficient tree plantings, and not a study of market potential. Market potential will be less than technical potential because some customers will not want trees planted in certain locations. Trees may conflict with a resident's desire to preserve access to the backyard, preserve existing views, maintain an open landscape for security reasons, retain solar access to pools, solar collectors, and vegetable gardens, and maintain a litter-free landscape. Market potential will change as customers attitudes about the value and benefits of trees change. Survey research is needed to determine the percentage of potential planting sites residents are willing to plant. Information on reasons people choose not to plant trees may be useful in marketing the program. With a relatively small amount of additional support from STF and SMUD this research could be accomplished during summer 1995. Information from field work and a questionnaire could provide more accurate estimates of actual tree planting potential in Sacramento County.

RESULTS AND DISCUSSION

In this chapter we describe characteristics of the residential structures sampled and the population of residential units. Results for each scenario are presented. For each scenario we initially present unadjusted data on the total numbers of tree sites, sizes, directions, and distances from the buildings. The overall mean number of tree sites and standard error of the estimated mean are presented. Estimated means and standard errors incorporate the tree-size adjustment. A second estimate of projected tree sites is presented with numbers adjusted to the medium-sized reference tree. The distribution of tree sites throughout Sacramento County are described and illustrated. In the discussion we compare the number of existing trees and potential tree sites among the four scenarios. We use adjusted data as a common basis for comparison. Appendices D to G contain detailed adjusted and unadjusted data by SubRAD for each of the four scenarios.

CHARACTERISTICS OF THE RESIDENTIAL UNITS

The target population of residential units in Sacramento County is 346,186 (SACOG 1995). Eighty-three percent (287,551) are 1-unit residences (i.e., single family detached), 12.6 percent (43,608) are 2 to 4 unit residences, and 4.3 percent (15,027) are mobile homes. The population of residential units is shown by SubRAD in Plate 1 (also see Table 1). We do not present data for 10 of the 71 SubRADs. Complete aerial photo coverage was unavailable for 8 of these SubRADs. No residential units were sampled in SubRADs 72 and 132 (Table 1). This is a minor omission. SACOG housing data indicate that there are 21 and 0 residential units in SubRADs 72 and 132, respectively.

We sampled 2,921 residential structures or 0.84 percent of the residential units in the target population. Eighty-eight percent of the structures were 1 story and 12 percent were 2 story. The average floor area (including garages, overhangs, covered porches) and lot area were 2,654 and 12,949 square feet, respectively. The front orientation of 44 percent of the sample structures was north and south, 22 percent faced east and west (Figure 4). Only 24 percent of the structures had intercardinal orientations (i.e., northeast, southeast, southwest, northwest).

SCENARIOS

Existing Trees

There are approximately 872,287 trees located within the 60-ft shading envelope of residential units in the study area. About 45 percent are medium-sized, 44 percent are small-sized, and 12 percent are large-sized trees.

Most trees (64%) are opposite walls facing cardinal directions (i.e., north, south, east, west),

with a relatively even distribution across directions. Similarly, remaining trees are distributed evenly across the intercardinal directions. Approximately 60 percent of existing trees are within 20 ft of the residential structure (i.e., adjacent), 29 percent are between 21 and 40 ft (i.e. near), and 10 percent are between 41 and 60 ft (i.e., far).

When the number of existing trees are adjusted to the medium-sized reference tree, the overall mean is 3 trees per residential unit with a standard error of 0.16. With 95 percent confidence the true mean is between 2.84 to 3.16. SubRADs with the greatest number of trees per residential unit occur in the City of Sacramento, north and northeast of Sacramento, Galt, and Rancho Murieta (Plate 2). SubRADs that ring the downtown area (e.g., Land Park, North Sacramento, East Sacramento) and are northeast of Sacramento (e.g., Arden-Arcade, Carmichael) contain the greatest number of trees in absolute terms (Plate 3).

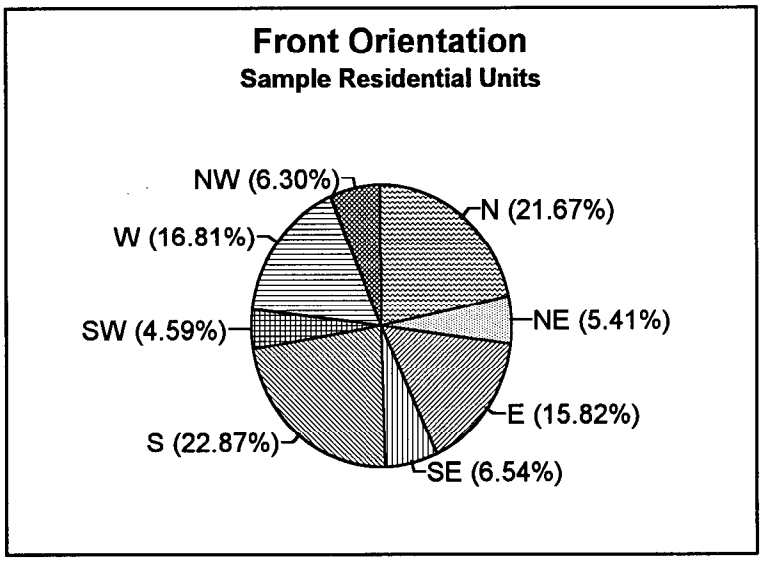


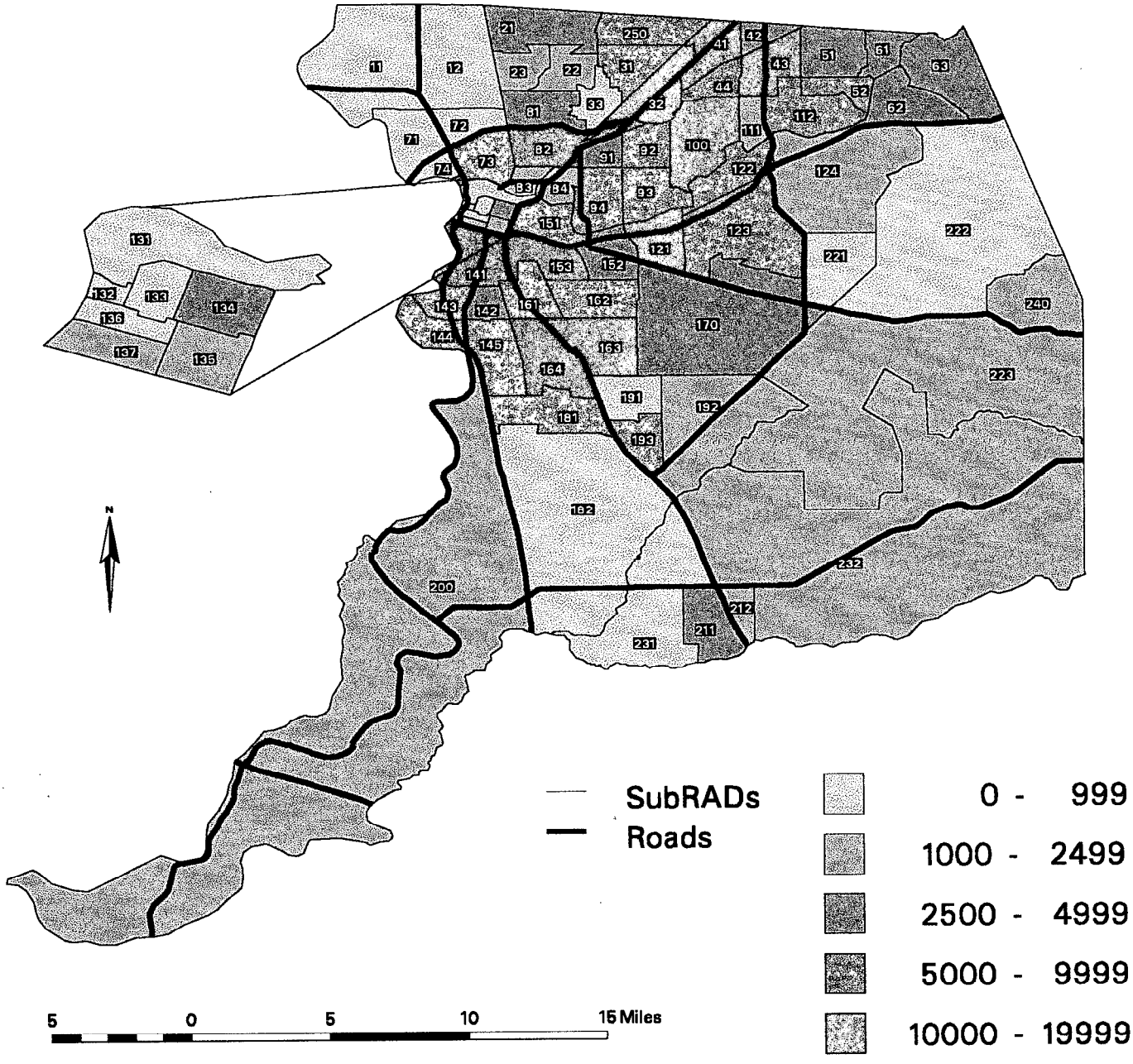
Figure 4. Distribution of front orientations for sample structures.

Tree Planting Potential - All Sites

The estimated number of potential tree planting sites is 678,371. Most sites are for medium (44%) and small trees (39%). Sixty-six percent of the sites are within 20 ft of the structures, 23 percent between 21 and 40 ft, and 11 percent between 41 and 60 ft. About two-thirds of the sites are opposite walls facing cardinal directions, with relatively more sites opposite south and north facing walls (18-21%) than west and east facing walls (13-15%). Slightly more tree sites are northeast and northwest (8-9%) than southeast and southwest (7%).

The overall mean is 3.15 tree sites per unit when the tree count is adjusted to the medium-sized tree. The standard error of the estimate is 0.09, with 95 percent confidence the true mean is

Residential Units



USDA Forest Service - PSW
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Plate 1

Existing Trees

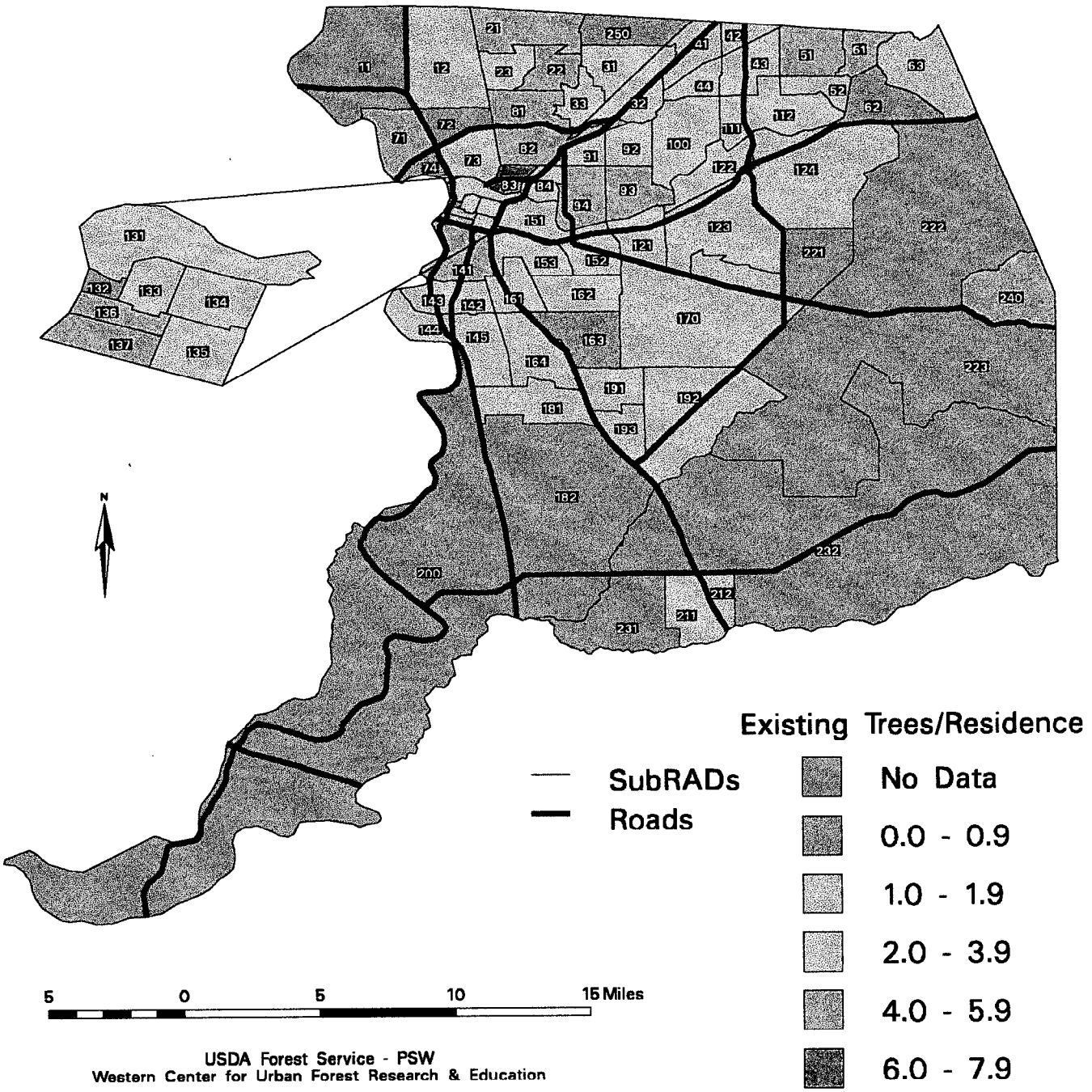

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Plate 2

Existing Trees

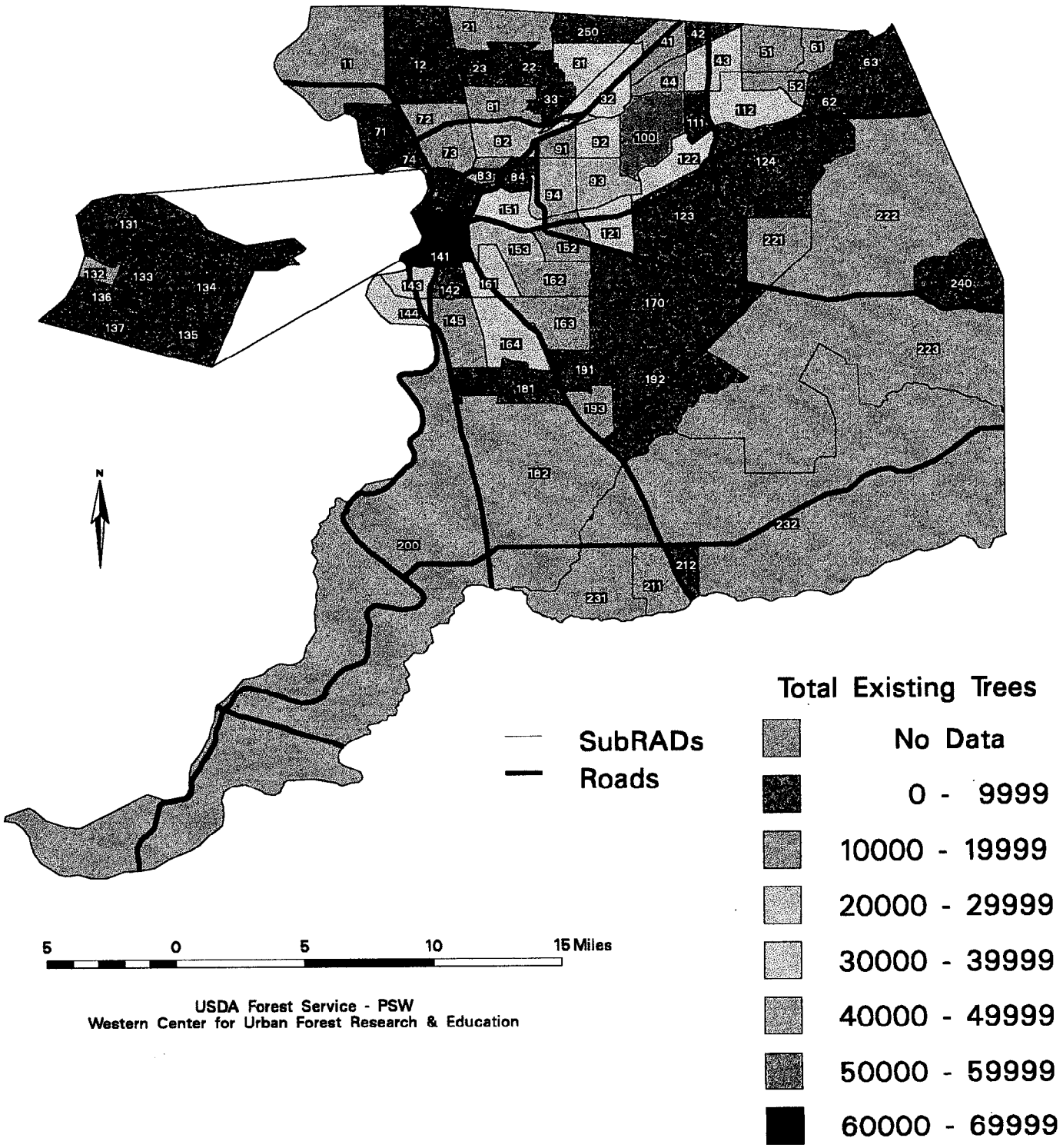

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Plate 3

Tree Planting Potential
All Sites

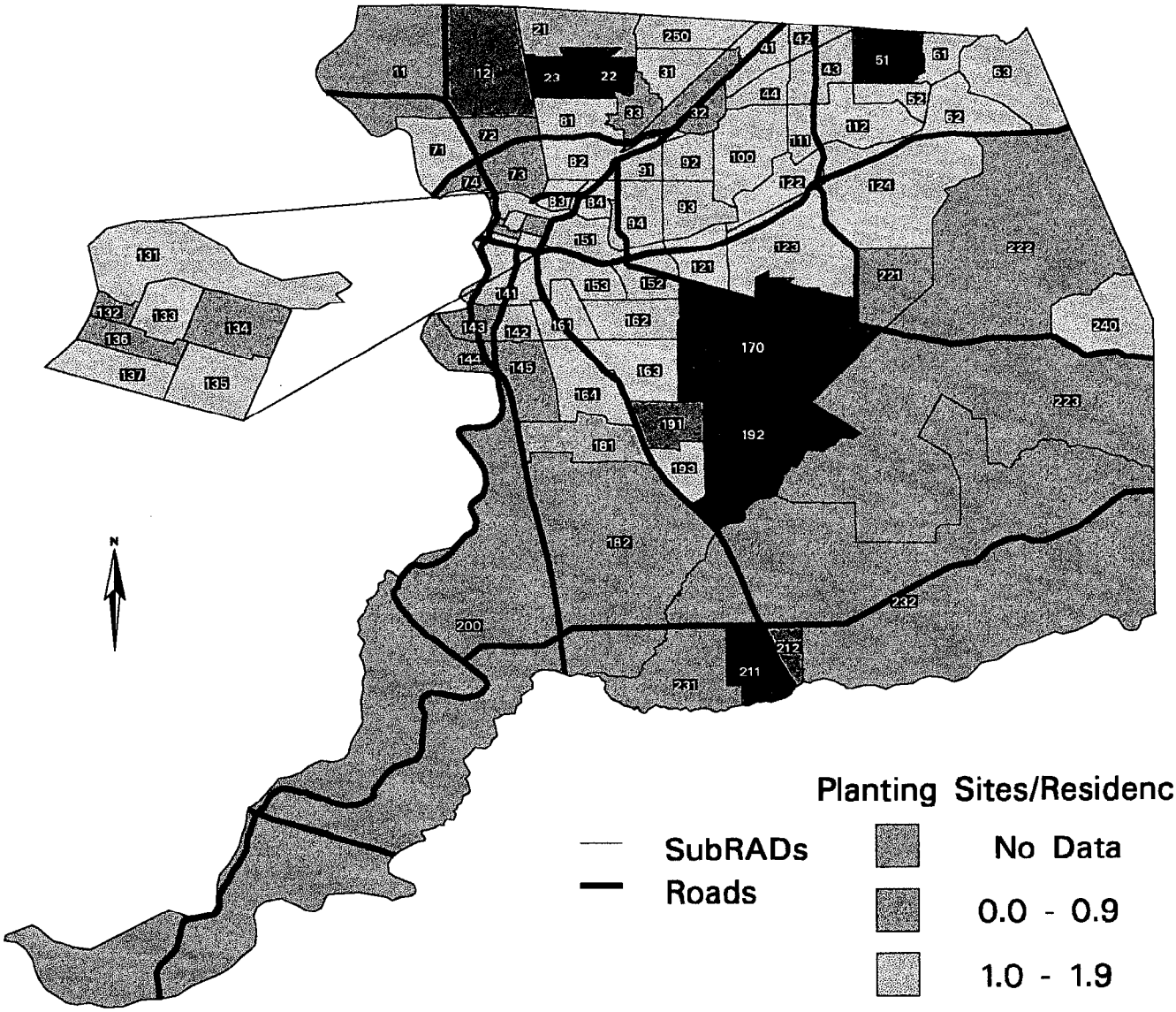

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Plate 4

Tree Planting Potential
All Sites

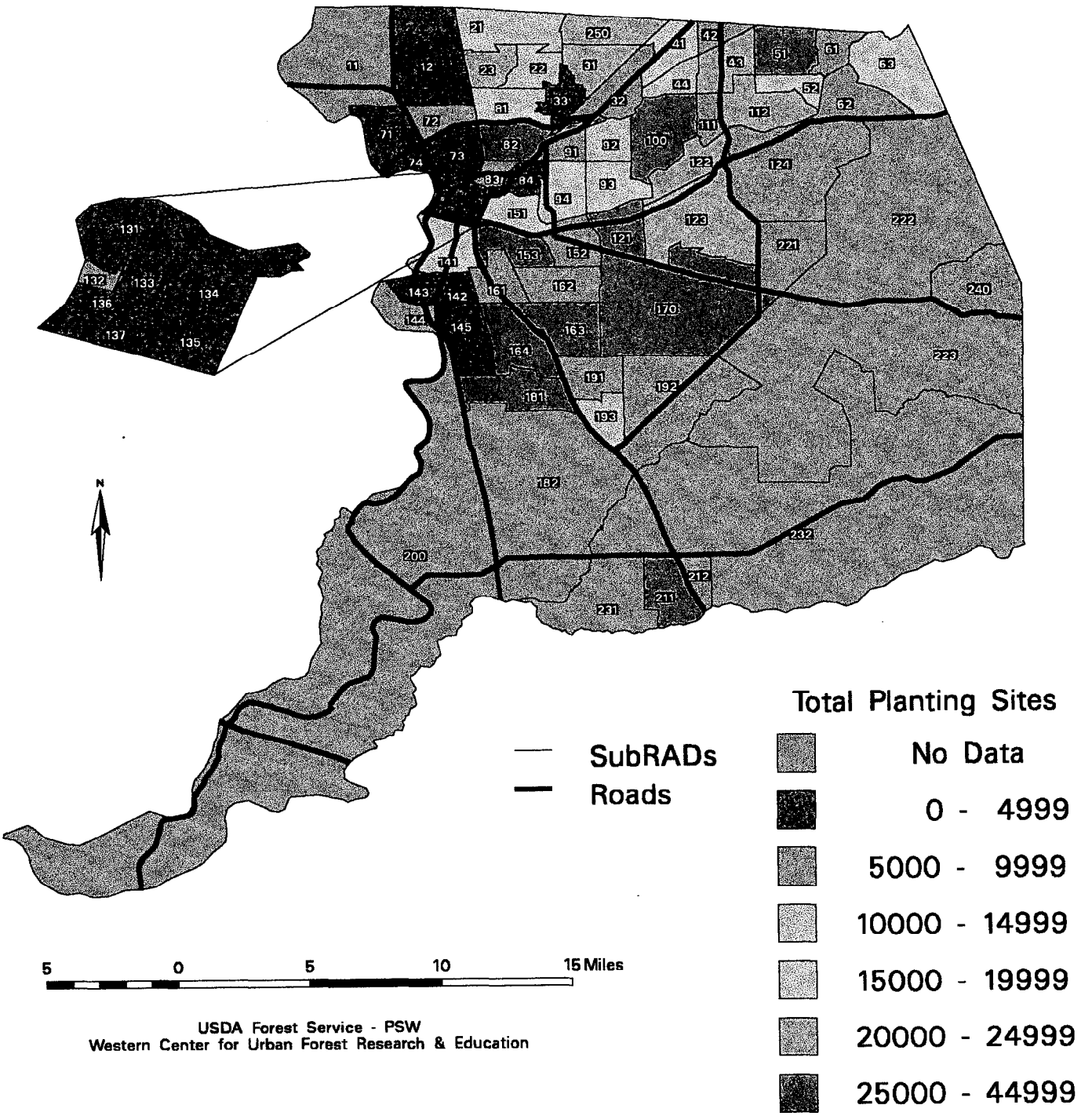

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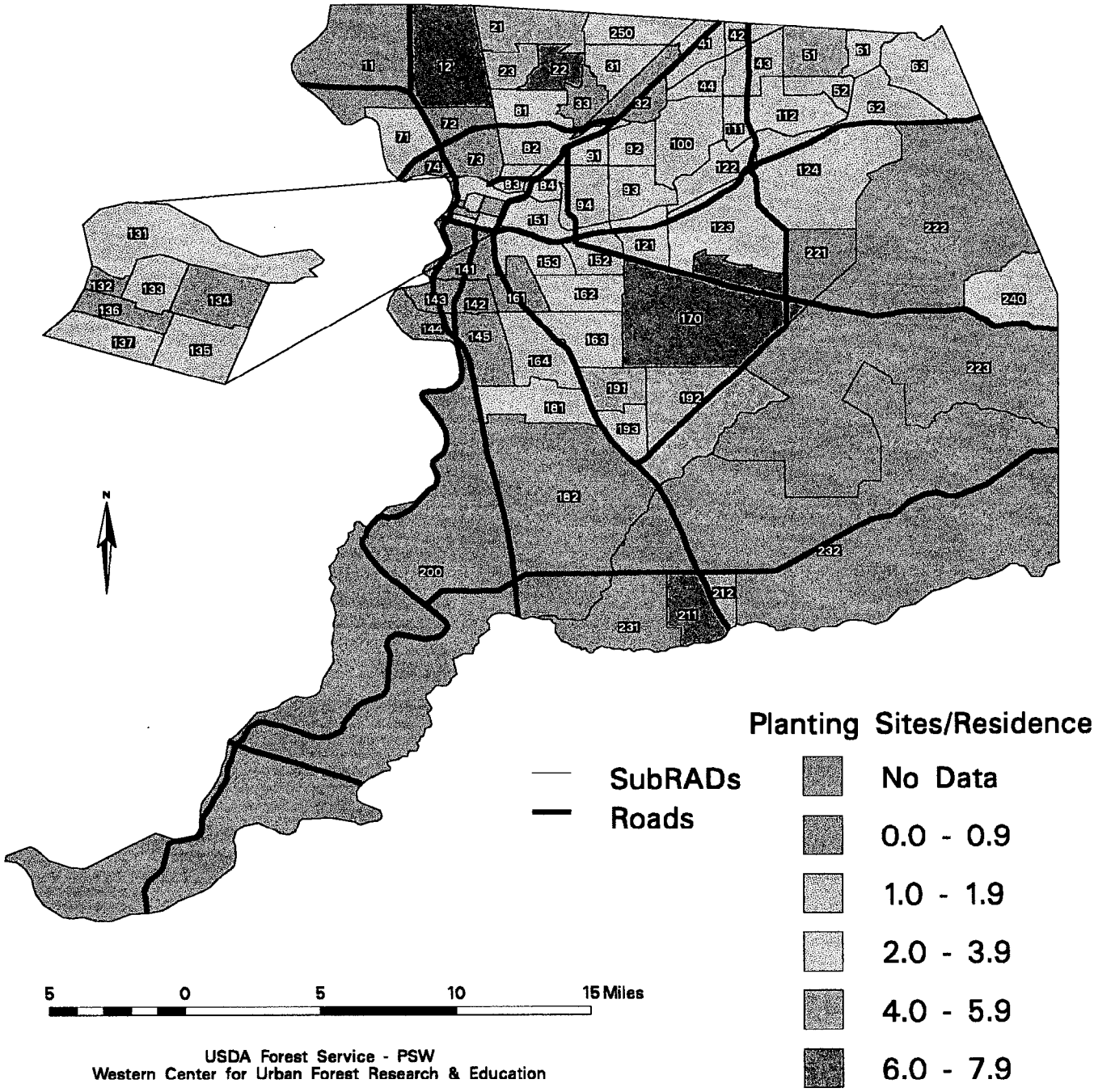
Plate 5

Tree Planting Potential
Sacramento Shade Guidelines



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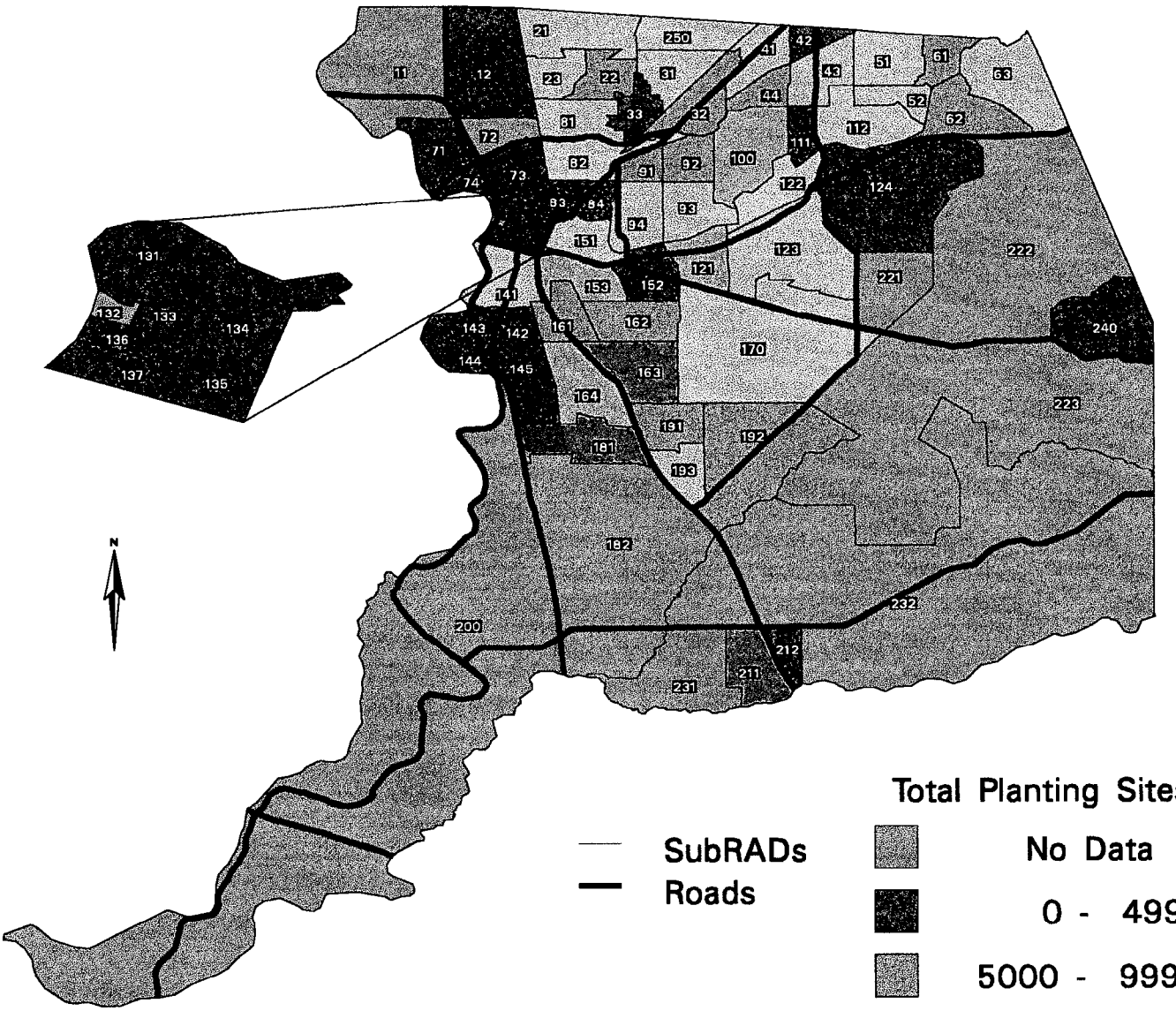
Sacramento Shade Guidelines:
Planting sites north and far from buildings are not considered (see text).

Plate 6

Tree Planting Potential
Sacramento Shade Guidelines



5 0 5 10 15 Miles

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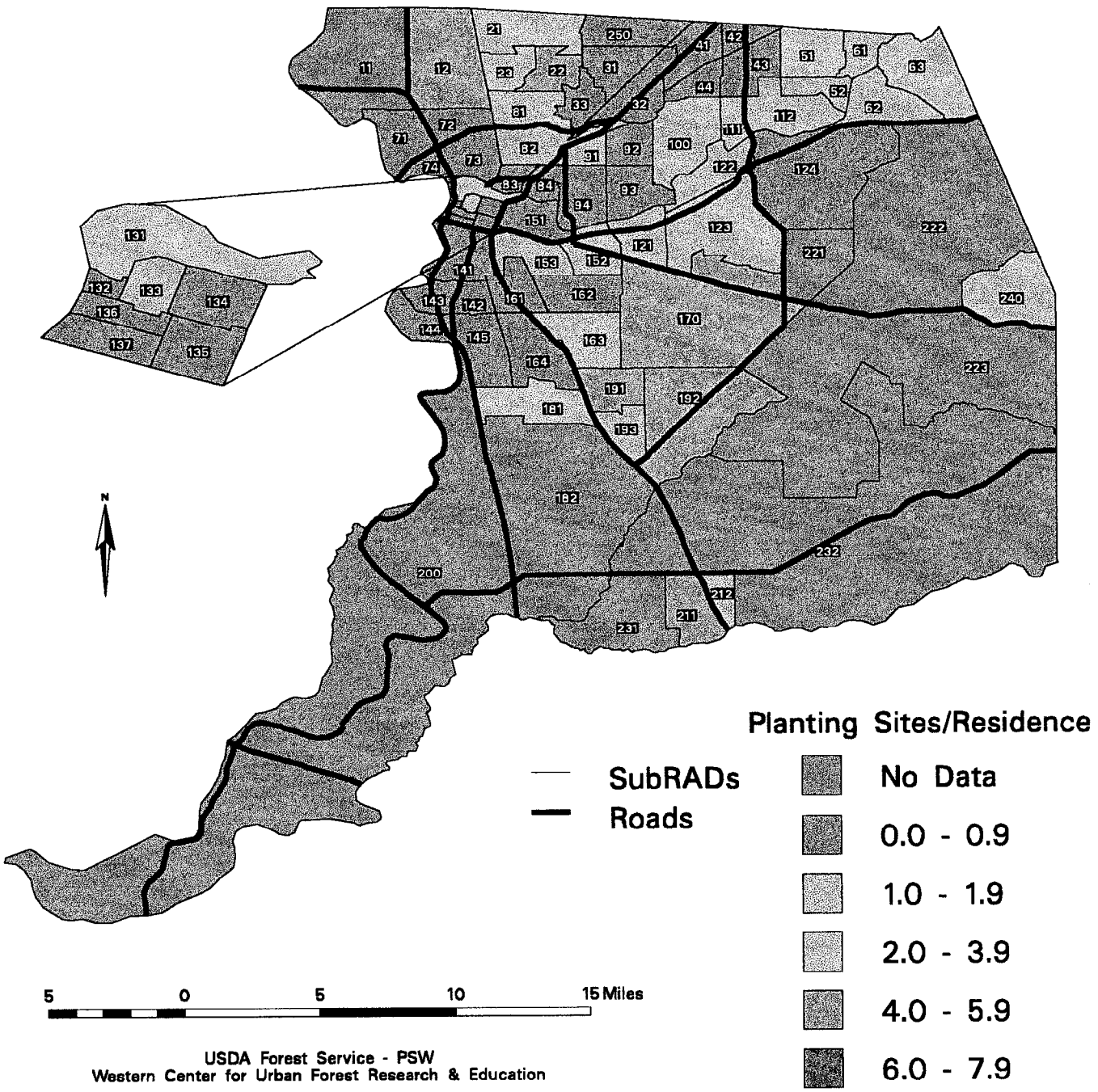
Total Planting Sites

- No Data
- 0 - 4999
- 5000 - 9999
- 10000 - 14999
- 15000 - 19999
- 20000 - 24999
- 25000 - 29999

Sacramento Shade Guidelines:
Planting sites north and far from buildings are not considered (see text).

Plate 7

Tree Planting Potential
Forest Service Guidelines

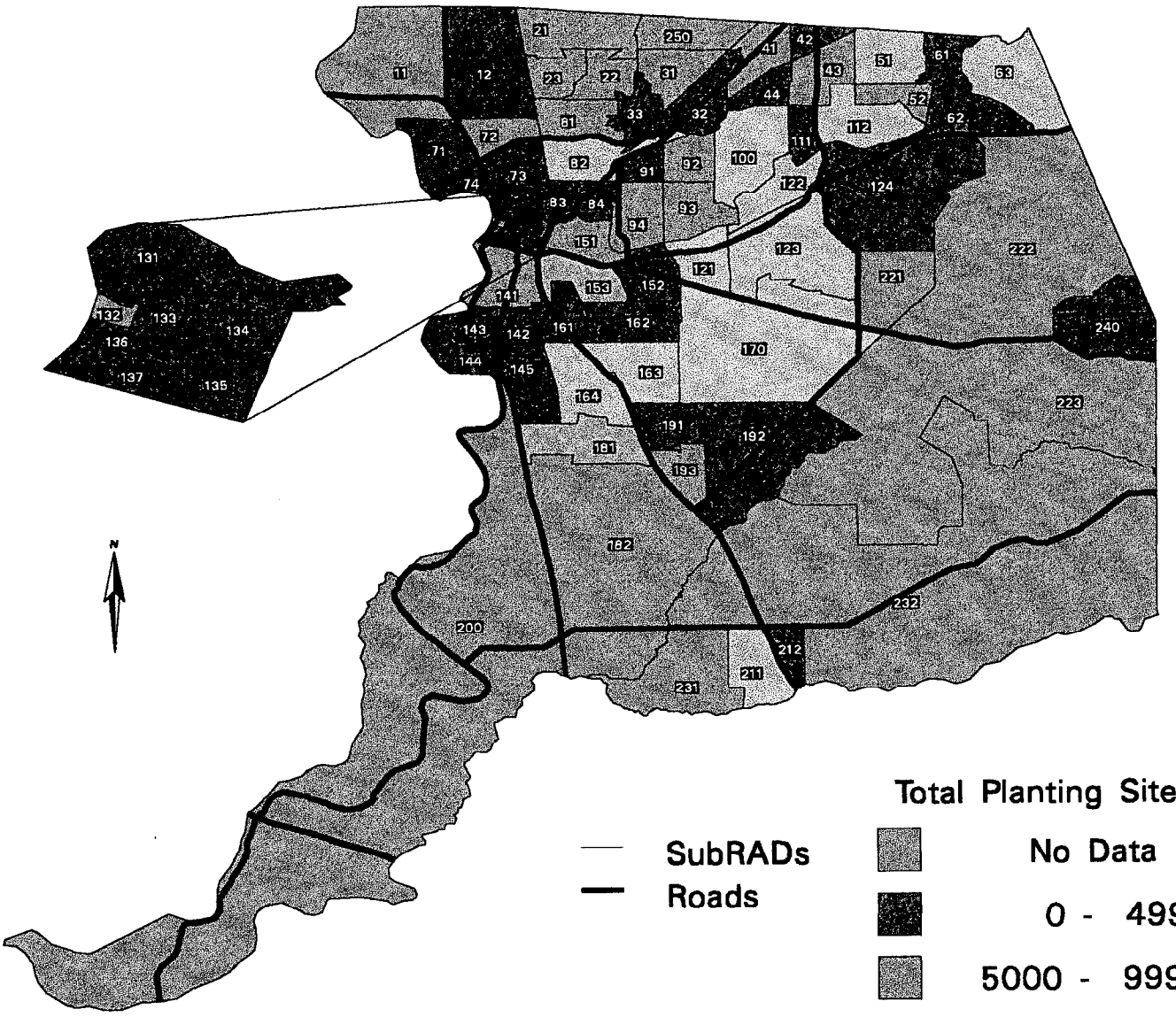


USDA Forest Service - PSW
Western Center for Urban Forest Research & Education

Forest Service Guidelines:
Based of cost-effectiveness analysis (see text).

Plate 8

Tree Planting Potential
Forest Service Guidelines



USDA Forest Service - PSW
Western Center for Urban Forest Research & Education

Forest Service Guidelines:
Based of cost-effectiveness analysis (see text).

Plate 9

between 2.97 to 3.33. The total adjusted number of potential tree planting sites is 844,192.

SubRADs with the most tree planting potential per residential unit are in areas such as Rio Linda-Elverta, Vineyard, Galt, Elk Grove, and Orangevale (Plate 4). These areas also have the greatest total number of potential planting sites (Plate 5). SubRADs containing the least potential for future tree planting include areas in downtown Sacramento, Meadowview and the Pocket, South Natomas, and Citrus Heights.

Tree Planting Potential - Sacramento Shade Guidelines

The Sacramento Shade siting guidelines do not permit planting north of buildings or at distances greater than 35 ft from building walls. These restrictions reduce the number of potential planting spaces from 678,372 to 473,549. The difference is 204,822 sites, or 30 percent of all potential sites. The distribution of potential sites by tree size class is similar to that for the All Sites scenario: 45 percent medium-sized trees, 40 percent small trees, and 16 percent large trees.

After adjusting the tree count to the medium-sized reference tree the overall mean is 2.11 sites per residential unit. With 95 percent confidence the true mean ranges between 1.99 and 2.23. There are approximately 576,157 potential tree planting sites when the count is adjusted for tree size.

Twenty-four percent of all tree sites are south of buildings, while 20 percent are opposite east walls and 18 percent are opposite west walls. Intercardinal sites are split nearly equally between east (19% northeast and southeast) and west (20% northwest and southwest) sides, but more tree sites are north (21% northeast and northwest) than south (17% southeast and southwest) of structures. Seventy-two percent of the potential tree sites are 10 to 20 ft from structures, while the remaining 28 percent are 21 to 40 ft away.

SubRADs with the greatest number of potential tree planting sites per residential unit generally occur in urbanizing areas along the State Route 50 corridor, south and east of Sacramento (e.g., Vineyard, Elk Grove, Franklin-Laguna, Galt), and to the north (North Natomas, Rio Linda-Elverta, Antelope) (Plate 6). With some exceptions (e.g., North Natomas) these SubRADs have among the highest numbers of total tree planting sites (Plate 7). Land Park (#141) and Carmichael (#100) have low potential per unit but relatively large numbers of potential sites because they contain more residential units than many other suburban and rural SubRADS.

Tree Planting Potential - Forest Service Guidelines

Benefit-cost ratios (BCR) for the 72 shading scenarios provided the basis for developing the Forest Service siting guidelines (Table 3). BCRs are the result of current estimates of future benefits from energy and capacity savings, as well as current program costs. Hence, BCRs are expected to change in the future as estimates of avoided energy costs and program costs change. We found 19 scenarios with BCRs of 1 or greater and 6 scenarios with BCRs between 0.5 and

0.99. Hence, 25 (35%) of the scenarios were classified as cost-effective and marginally cost-effective. The distribution and magnitude of BCR values in Table 3 reflect the impacts of tree/building/solar geometry on the amount of irradiance obstructed, as well as the relative pricing of avoided energy and capacity. The largest BCRs occur for trees located west of the building, with values increasing with tree size and decreasing with distance from the building. Generally, the larger a tree is and the closer it is to the building, the more shade it provides. The large benefit from west shade compared to east shade is largely due to the relatively high avoided cost of capacity, which occurred from 1 to 8 p.m. on the buildings' peak cooling day (August 7). However, an exception to the pattern of BCRs is the 4.68 value for the large, west tree adjacent to the building. The BCR is less than the BCR for the large tree that is 15-ft farther from the building ("near" tree, 5.11). This anomaly is due to irradiance reaching the west wall under the adjacent tree's crown earlier in the afternoon because it is so close to the building. In essence, the large tree adjacent to the west wall is shading more of the roof and less of the wall than is the near tree. Wall shade is relatively more important in the afternoon than roof shade because a large percentage of solar gain is through windows.

Table 3. Benefit-Cost Ratios for the 72 Shading Scenarios[a].

	North	Northeast	East	Southeast	South	Southwest	West	Northwest
Small Tree (17-ft tall, 15-ft spread)								
Adjacent[b]	0.02	0.00	0.31	0.06	0.16	0.14	2.37	0.11
Near	0.00	0.00	0.06	0.01	0.00	0.03	1.39	0.04
Far	0.00	0.00	0.01	0.00	0.00	0.00	0.99	0.02
Medium Tree (35-ft tall, 30-ft spread)								
Adjacent	0.04	0.15	1.04	0.87	2.06	1.48	4.12	0.57
Near	0.00	0.00	0.76	0.12	0.22	0.26	4.05	0.06
Far	0.00	0.00	0.21	0.02	0.01	0.08	2.83	0.04
Large Tree (52-ft tall, 45-ft spread)								
Adjacent	0.06	0.62	1.29	1.97	2.68	2.24	4.68	1.24
Near	0.01	0.00	1.17	0.35	1.39	1.30	5.11	0.25
Far	0.00	0.00	0.72	0.11	0.12	0.26	4.31	0.06

[a] Solid black line outlines cost-effective shading scenarios with BCR of 1 or more, double line outlines marginally cost-effective scenarios with BCR of 0.5 - 0.99.
[b] Distances are feet from building wall for SPS simulations: adjacent = 15, near = 30, far = 50.

Our cost-effectiveness analysis suggests that small trees are only cost-effective on the west. Medium-sized trees are cost-effective at directions between east and northwest, but need to be located relatively close to the building unless placed directly east or west. There is more flexibility in siting large trees, with cost-effective trees at all directions except north and northeast.

It should be recognized that this analysis assumes 1994 avoided costs and program expenditures and is limited to a single prototype building. Higher BCRs are likely for less energy-efficient structures and lower BCRs for more energy-efficient buildings. The window area of our prototype was evenly distributed, but this is true of very few real buildings. In reality, we expect the BCRs to be quite sensitive to the amount and orientation of window area. Our BCRs for intercardinal shading simulations are less than BCRs we anticipate if building walls were also intercardinal. Intercardinal trees are further from the wall's center and therefore produce less wall shade when opposite the corner of cardinal buildings than when directly opposite the center of an intercardinal wall. Our analysis does not include increased heating costs from winter shade or potential air conditioning savings associated with lower daytime summer temperatures that result from the aggregate effect of trees on urban climate. Finally, we have made conservative assumptions regarding tree mortality that remain to be observed.

Assuming these restrictive guidelines, there are approximately 262,798 planting sites in locations where trees are cost-effective and marginally cost-effective. About 70 percent of the total number of potential planting sites are ineligible for planting in this scenario. More sites are available for medium (60%) and large (27%) trees than for small trees (13%). Seventy-five percent of all sites are opposite west (28%), south (24%), and east (24%) walls. Most of the remaining sites occur to the southwest (8%) and northwest (7%). Seventy-eight percent of the potential tree sites are adjacent to buildings, 18 percent are near, and 4 percent are far.

The overall mean is 1.5 sites per residential unit. The SE is 0.07 so with 95 confidence the true mean is between 1.36 and 1.64. The total adjusted number of potential tree planting sites is 395,163.

Tree planting potential varies slightly from the pattern described for the Sacramento Shade scenario. SubRADs along the State Route 50 corridor have less potential with the Forest Service guidelines, dropping from 2 to 4 sites per unit to 1 to 2 per unit (Plates 8 and 9). In Antelope (#250) the number of sites per unit drops from 2 to 4 with Sacramento Shade guidelines to 0 to1 with Forest Service guidelines. A possible explanation for this decrease is that relatively small lots characteristic of this area may reduce the potential for larger-sized trees, which constitute more of the Forest Service sites than Sacramento Shade sites.

DISCUSSION

Given assumptions of this analysis, for every 100 existing trees there are approximately 86 future planting sites if all potential sites within 60 ft of residential units are considered (Table 4). Although we estimate that there are more existing trees than future tree sites, the estimated mean

number of potential sites is greater than the mean number of existing trees (3.15 compared to 3.0). This discrepancy is probably due to differences in the way the mean is estimated and tree sites are counted. The overall mean is the average of SubRAD means, so extreme values for a SubRAD can have considerable influence on the overall mean. For example, rural SubRADs may have higher mean numbers of potential tree sites than urban SubRADs because of relatively large lot sizes, although total planting sites may be lower in rural areas because they contain relatively few residential units. As a result, the impact of a rural SubRAD's large mean on the overall mean may be greater than the impact of its relatively small number of planting sites on the total count.

Shading Guidelines

As more stringent siting guidelines are applied the number of potential sites for shade tree planting dwindle. The Sacramento Shade guidelines eliminate nearly one-third of all potential sites, while the Forest Service guidelines eliminate over half of all planting sites (Table 4). These "residual" sites provide substantial opportunity for tree planting that can produce air conditioning savings associated with lower summer temperatures and reduced wind speeds, as well as other environmental (e.g., air cleansing, rainfall runoff reduction, wildlife habitat), economic (e.g., increased property values), and aesthetic benefits. The Forest Service is conducting the Sacramento Urban Forest Ecosystem Study to quantify these benefits, as well as tree management costs.

Our benefit-cost results indicate that Sacramento Shade's current policy of not siting trees north of buildings is sound. However, BCRs for medium and large trees sited 50-ft west of the prototype were greater than 1.0 and therefore cost-effective (Table 4). Sacramento Shade siting guidelines that prohibit planting beyond a distance of 35-ft from building walls should be evaluated, with permissible distances extended to the west and perhaps the east. Guidelines for tree planting to the southeast, south, and southwest should emphasize medium and large trees located 10 to 30 ft from the house. Planting of small trees to the south is not cost-effective.

While Sacramento Shade's current guidelines could be fine-tuned to better incorporate sun/tree/building geometry, we do not recommend adopting strict guidelines as exemplified in the Forest Service scenario. Ideally, siting guidelines provide the limits within which knowledgeable foresters assist residents site trees to maximize air conditioning savings. The forester needs to consider which trees are most suitable at each potential site, the likely impact of shade from trees at each site on the building air conditioning energy use, and the customer's needs with respect to compatibility of new trees with the overall landscape. Strict guidelines may hinder the ability of foresters to find satisfactory solutions. For example, in our experience air conditioning savings from tree shade are quite sensitive to the amount and orientation of window area. Trees planted northwest of a home with large amounts of northwest-facing window area may be very cost-effective, although the Forest Service guidelines indicate that this is seldom the case.

Table 4. Adjusted and Projected Counts of Existing Trees and Potential Tree Planting Sites.

	Existing Trees		All Potential Tree Planting Sites		Sacramento Shade Guidelines		Forest Service Guidelines	
	No.	%	No.	%	No.	%	No.	%
Total Sites[a]	985,187		844,192		576,157		395,163	
Mean[b]	3.00		3.15		2.11		1.50	
SE[c]	0.08		0.09		0.06		0.07	
Tree Size[d]								
Small	379,004	43.5	265,227	39.1	186,083	39.3	34,919	13.3
Medium	389,462	44.7	297,081	43.8	212,902	45.0	157,331	59.9
Large	103,821	11.9	116,063	17.1	74,564	15.8	70,548	26.8
Direction								
North	165,729	16.8	171,200	20.3	0	0.0	0	0.0
Northeast	76,859	7.8	69,925	8.3	57,066	9.9	11,923	3.0
East	138,460	14.1	127,377	15.1	113,392	19.7	93,888	23.8
Southeast	93,465	9.5	63,354	7.5	50,326	8.7	23,018	5.8
South	163,080	16.6	157,670	18.7	141,327	24.5	94,589	23.9
Southwest	85,283	8.7	64,917	7.7	50,736	8.8	33,418	8.5
West	165,658	16.8	111,085	13.2	99,447	17.3	111,085	28.1
Northwest	96,643	9.8	78,665	9.3	63,863	11.1	27,242	6.9
Distance from Building[e]								
Adjacent	567,160	57.6	515,316	61.0	394,581	68.5	288,025	72.9
Near	309,567	31.4	214,457	25.4	181,576	31.5	86,313	21.8
Far	108,451	18.3	114,420	13.6	0	0.0	20,825	5.3

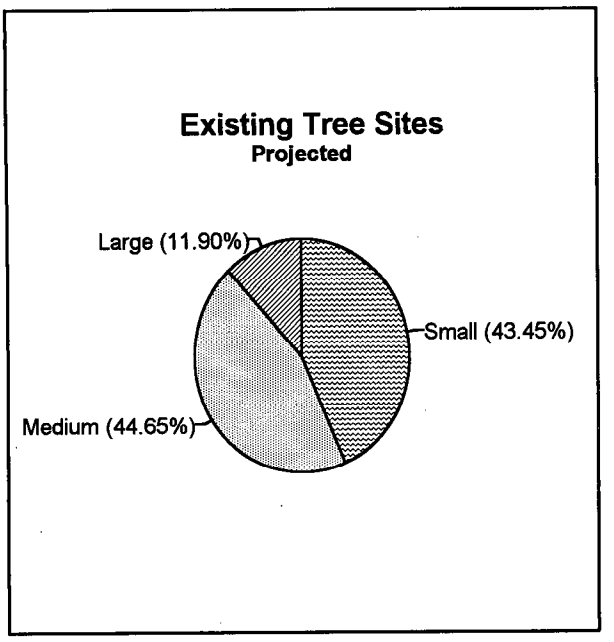
[a] Total number assuming tree size adjustment to the medium-sized reference tree.
[b] Overall (unweighted) mean per residential unit.
[c] Standard error of the overall mean.
[d] Tree sizes in terms of crown spread in feet: small = 10-20, medium = 21-40, large = 41-60.
[e] Distances from structure in terms of feet: adjacent = 10-20, near = 21-40, far = 41-60.

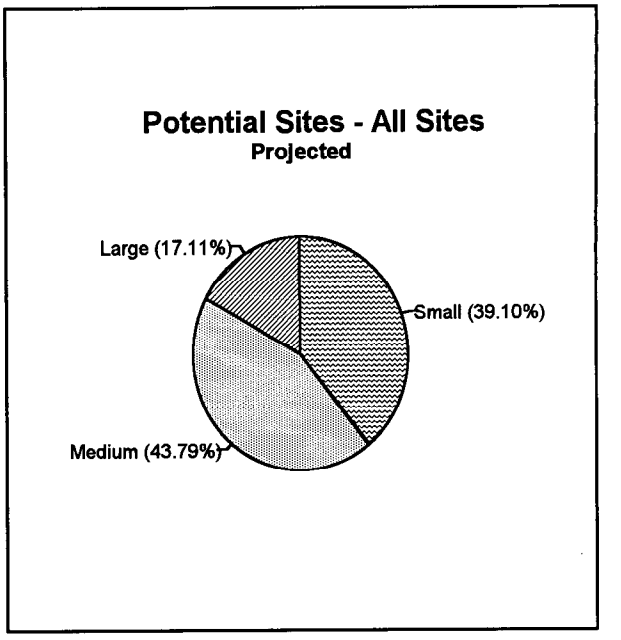
We recommend providing foresters with a shading envelope that establishes normal boundaries for cost-effective tree planting, and supplementing this with more specific training on strategic tree siting. Training might focus on identifying locations where trees are not likely to be cost-effective, as well as prioritizing remaining locations with respect to their savings potential. Such training might consist of classroom and field work covering topics such as: sun/building/tree geometry, solar heat gain in buildings, tree growth and mortality. By training foresters in cost-effective shade tree siting they will be better able to eliminate siting of ineffective trees and increase net benefits by strategically siting the remaining trees for maximum air conditioning savings. Staff of the Western Center for Urban Forest Research and Education are ready and willing to assist STF and SMUD with such an effort.

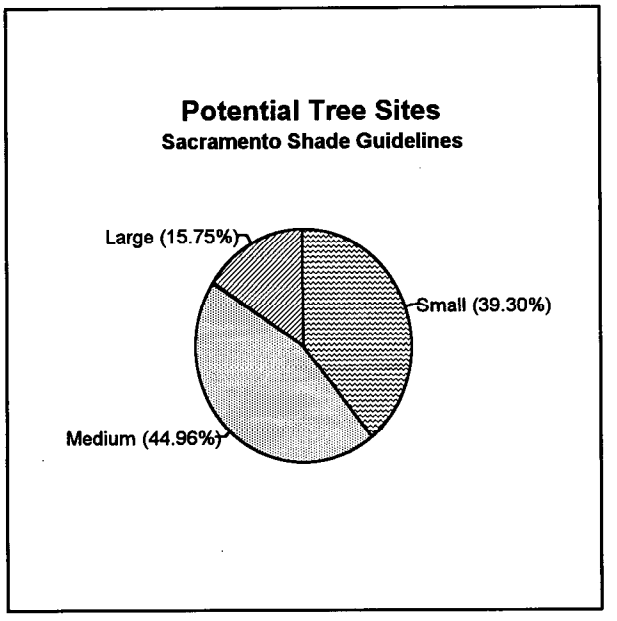
Tree Size

The distribution of existing trees and planting sites by tree size is quite similar except for the Forest Service guidelines (Figure 5). Generally, most sites are for medium (45%) and small-sized (39-43%) trees. Narrow side-yards and other spatial constraints in residential settings mean that 80 to 90 percent of existing trees and tree planting opportunities are for trees that do not exceed 40-ft crown spread. Large trees make up 12 percent of the existing tree population and 16 to 17 percent of potential sites in the All Sites and Sacramento Shade scenarios. This result seems logical given the decision rule that required interpreters to select the largest tree size that each space could accommodate.

Because the Forest Service guidelines are based on shading simulations and large trees produced higher BCRs than smaller trees in most locations, there are relatively more sites for large and medium trees than with the Sacramento Shade guidelines (27% versus 16% for large and 60% versus 45% for medium trees). There are over 265,000 sites for small trees in the All Trees scenario, but only about 35,000 (13%) of these sites are eligible for tree planting in the Forest Service scenario.







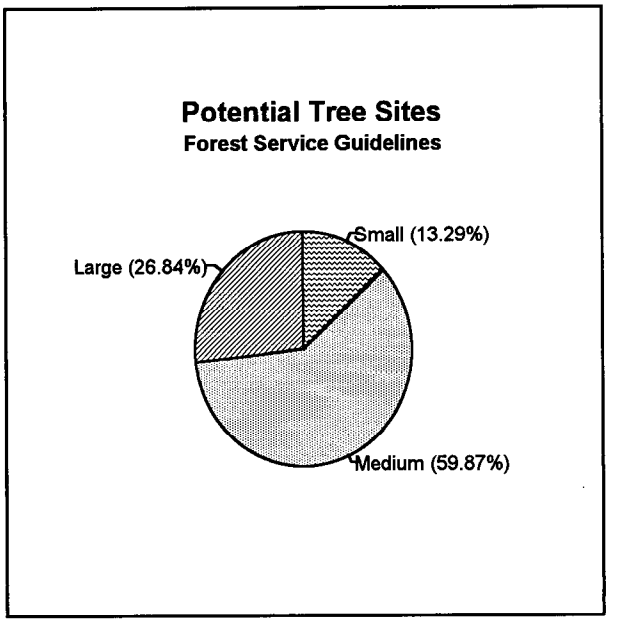


Figure 5. Distribution of tree sites by size for each scenario.

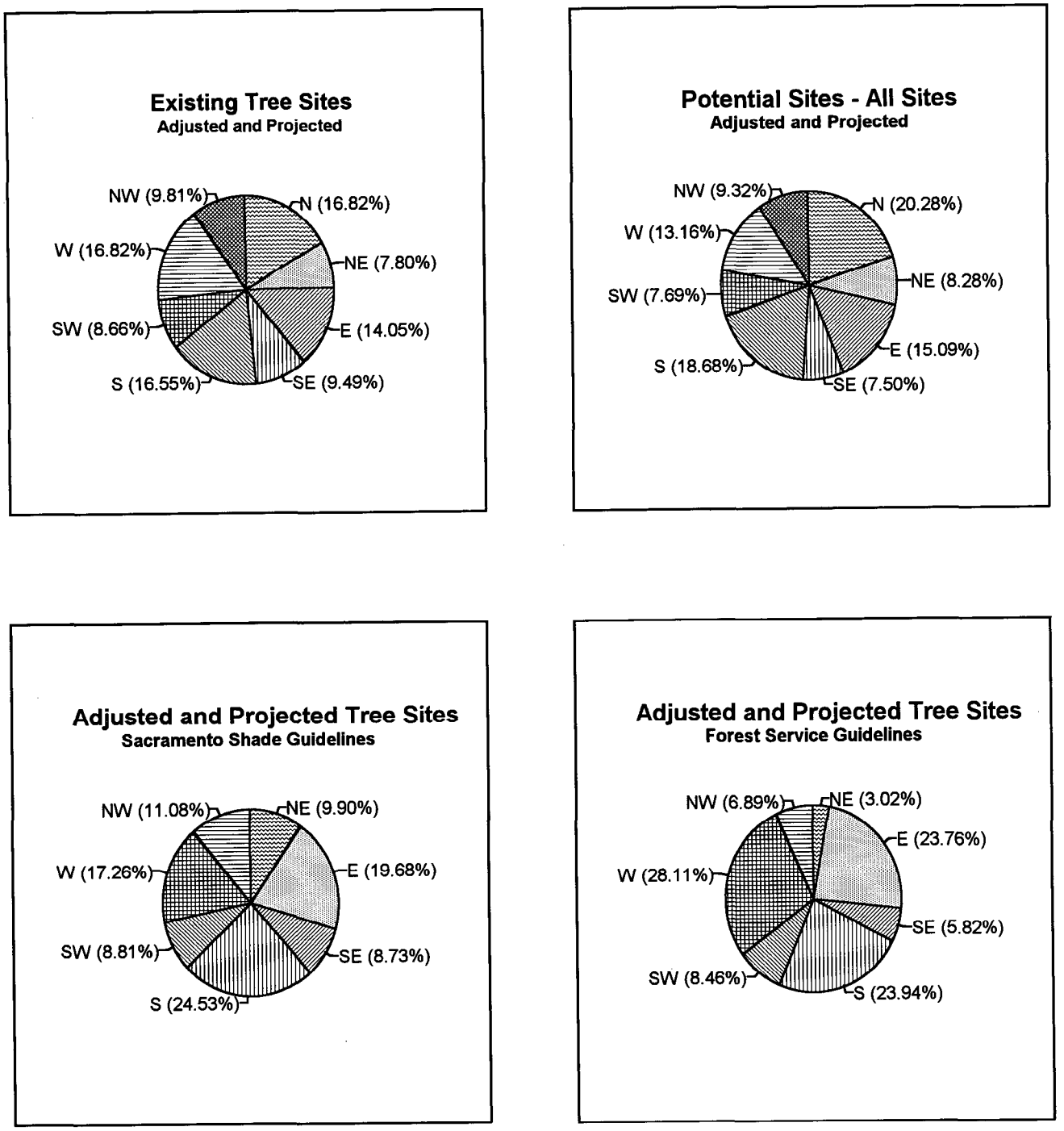


Figure 6. Distribution of tree sites by direction for each scenario.

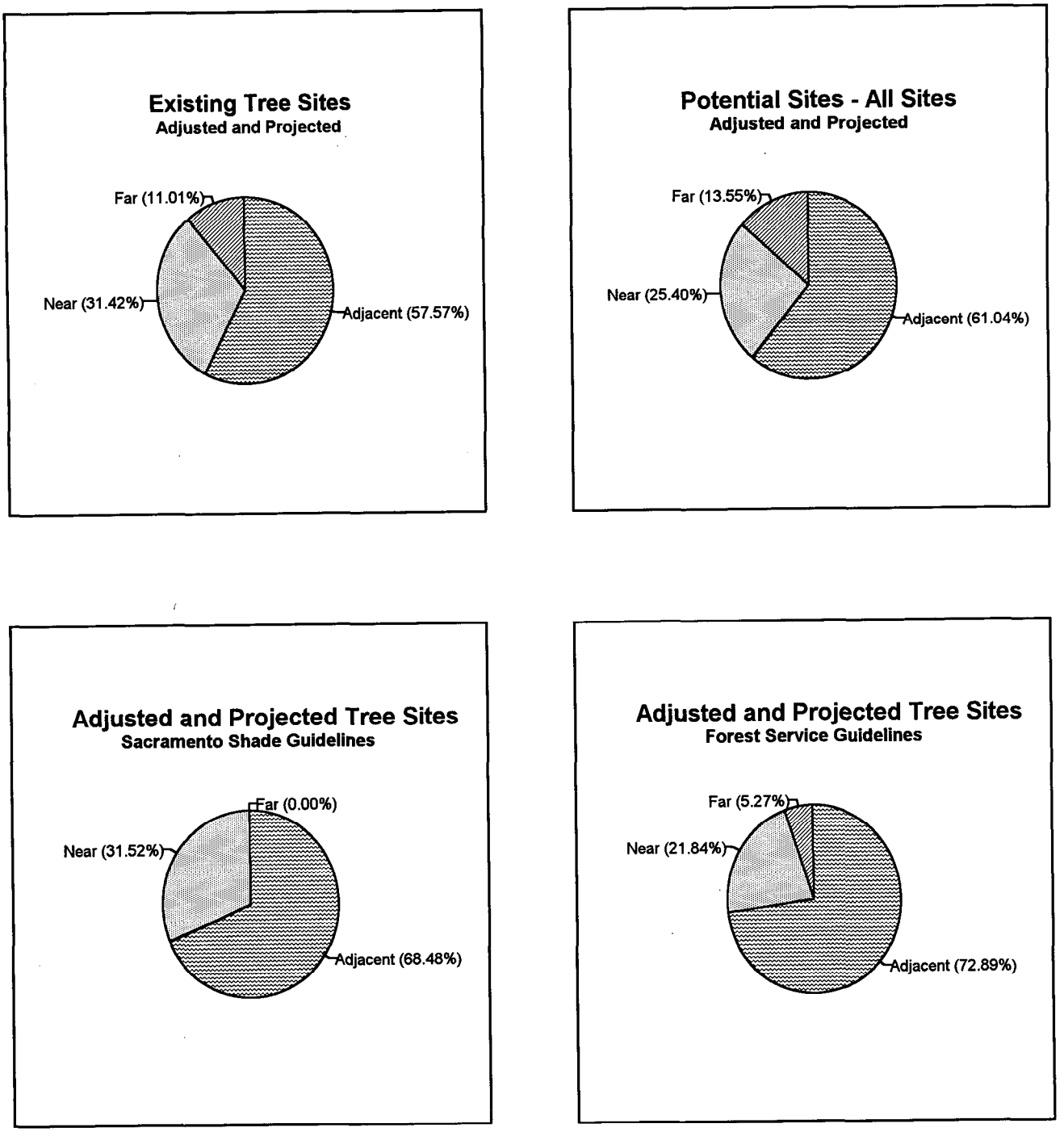


Figure 7. Distribution of tree sites by distance for each scenario.

Direction

The distribution of tree sites by direction is related to building orientation and lot layout. Generally, in densely developed areas residences are rectangular with the shortest walls facing the street. In suburban settings the longest walls often face the street. In our sample the fronts of nearly half of the structures face north and south, while 22 percent face east and west (Figure 4). Relatively few face an intercardinal direction. From this fact one can infer that most residential streets in Sacramento County run east-west and north-south. It is not surprising that 34 percent of existing trees and 39 percent of all potential sites are opposite north- and south-facing walls (Figure 6). Unfortunately, air conditioning savings from tree shade is negligible for about half of these sites that are located to the north. Therefore, tree sites opposite east and west walls of buildings will provide the greatest opportunities to maximize energy benefits from tree shade. Most of these planting opportunities will be at homes along north-south running streets. Cooling savings will be enhanced by the fact that he largest amount of window area faces front and back for most residences. For example, in the case of a building on a north-south street facing east, sizable air conditioning savings could be obtained from trees in the front (east) and back (west) yards, front side yard (southeast), and back side yards (southwest and northwest).

Because Sacramento Shade guidelines prohibit plantings north of buildings the relative percentage of tree sites in each of the remaining 3 cardinal directions increase 4 to 5 percent compared to the All Tree scenario. Forest Service guidelines show a strong bias to west sites (28% versus 17% for Sacramento Shade) because of their cost-effectiveness. The most frequent direction for Sacramento Shade sites is south (25%) because so many structures have a north-south orientation (Figure 6).

Distance

In all scenarios, most tree sites are adjacent and relatively few sites are far from buildings (Figure 7). To some extent this result reflects our decision rule to locate potential tree sites as close to the building as possible, but not within 10-ft of walls, paving, property lines, or existing/future tree canopy. However, the fact that 58 percent of existing trees are adjacent to buildings suggests that residents plant many trees within 20-ft of structures they inhabit. The distribution of existing and potential sites in the All Trees scenario is relatively similar.

The percentage of tree sites adjacent and near is more pronounced for the Sacramento Shade and Forest Service scenarios than for the All Sites scenario. In the first case no trees are eligible at the far location and in the second case, only trees due west are cost-effective when planted far from the prototype building. Fortunately, there are ample sites for tree planting relatively close to buildings, and at these locations trees shade the most wall area for the longest period of time.

Future Research

Data contained in this study are a valuable resource for the STF and SMUD. As new siting guidelines evolve these data can be used to estimate numbers of potential planting sites for proposed sets of guidelines. Additional analyses could be conducted to identify relations between parameters such as potential tree sites and building age, lot size, house size, and geographic location. This information may be useful in program marketing.

Future work could combine data from this study and the USDA Forest Service Impact Evaluation to project air conditioning savings from alternative planting scenarios on a service area-wide basis. Geographic differences in housing stock, existing tree cover, future planting potential, and climate could be incorporated to project energy (kWh) and capacity (kW) savings for each SubRAD. This product would provide program managers with a powerful tool for evaluating future impacts of different allocations of program resources.

Scientists at the Western Center for Urban Forest Research and Education are capable of assisting the STF and SMUD develop training and evaluation materials. If maximizing energy and capacity savings for each tree planted, we can use existing simulation tools and the SMUD Impact Evaluation database to illustrate how this is best accomplished for selected properties.

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APPENDICES

Appendix A - Tally Sheet
Appendix B - Micropas Simulation Input and Output for Prototype Building
Appendix C - Cost-Effectiveness Analysis Example
Appendix D - Data for Existing Trees Scenario
Appendix E - Data for Tree Planting Potential - All Sites Scenario
Appendix F - Data for Tree Planting Potential - Sacramento Shade Scenario
Appendix G - Data for Tree Planting Potential - Forest Service Scenario

APPENDIX A

Technical Potential Tally Sheet (for Residential [1-3 family] land use only)

RAD #:_____ SubRAD #:_____ Photo # :_____ Nearest grid location: _____

Land Cover Category: # of stories: 1 2 3

Orientation of front of house: N NE E SE S SW W NW

Avg. length of the house from side to side (to 5ft): Avg. length of the lot from side to side (to 5 ft):

Avg. length of the house from back to front (to 5ft): Avg. length of the lot from back to front (to 5 ft):

% impervious area on lot (include house, garage, driveway, sidewalks, patios): %

Quad	Existing Trees			Future Trees			Totals	
	S	M	L	S	M	L	ET	FT
North, Adjacent								
North, Near								
North, Far								
Norheast, Adjacent								
Northeast, Near								
Northeast, Far								
East,Adjacent								
East, Near								
East, Far								
Southeast, Adjacent								
Southeast, Near								
Southeast, Far								
South, Adjacent								
South, Near								
South, Far								
Southwest, Adjacent								
Southwest, Near								
Southwest, Far								
West, Adjacent								
West, Near								
West, Far								
Northwest, Adjacent								
Northwest, Near								
Northwest, Far								
Totals								

FORMATTED INPUT Page 1 FORMAT

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Run-1 story post-83 base case  Project-SMUD shade tree impact  Date-05/03/95
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Input file 'SAC1BC3J' last edited on 03/01/95

BUILDING

RUN FEATURES

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 1> RUN TITLE (25 char) ............................ 1 story post-83 base case
 2> PROJECT TITLE (25 char) ........................ SMUD shade tree impact an
 3> DOCUMENTATION AUTHOR (25 char) ................. J. R. Simpson
BUILDING
 4> TYPE (Single, SingleAttached, MultiFamily) ..... Single
 5> CONSTRUCTION (New, Addition, Existing, etc) ..... New
 6> FRONT ORIENTATION (Compass deg or Cardinal) ..... 90
 7> NUMBER OF STORIES (1 or more) ................... 1
RESEARCH
 8> COMPLIANCE RUN (Compliance, Research) ........... Research
 9> CEC ASSUMPTIONS (Reference) ..................... Reference
 10> WIND CORRECTION FACTOR (fraction) ............... .25
 11> TIME OF USE SCHEDULE NAME ....................... TOU
 12> SHADOW PATTERN SIMULATOR FILE NAME ............. None
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SITE AND WEATHER DATA

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 1> WEATHER DATA TYPE (FullYear, ReducedYear) ....... FullYear
 2> CEC CLIMATE ZONE (01 thru 16) ................... 12
 3> WEATHER DATA FILE NAME (CTZ03, CTZ12, etc) ...... CTZ12S92
 4> LATITUDE (Degrees or Default) ................... Default
 5> LONGITUDE (Degrees or Default) .................. Default
 6> TIMEZONE (1 to 8 or Default) .................... Default
 7> GROUND REFLECTIVITY (fraction) .................. 0.15
 8> GROUND TEMPERATURE (deg F) ...................... 65
 9> ANNUAL: LATENT LOADS FRACTION ................... 0
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HVAC SIZING

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 1> SIZING LOCATION (25 char) ....................... SACRAMENTO AP
 2> INTERIOR SHADING ON SOLAR GAIN CALCS (Yes, No) .. No
 3> EXTERIOR SHADING ON SOLAR GAIN CALCS (Yes, No) .. No
 4> OVERHANG SHADING ON SOLAR GAIN CALCS (Yes, No) .. No
 5> HEATING INDOOR DESIGN TEMPERATURE (deg F) ....... 70
 6> COOLING INDOOR DESIGN TEMPERATURE (deg F) ....... 78
 7> SIZING LATENT LOADS FRACTION (fraction) ......... 0.20
```

CALCULATIONS AND REPORTS

```
CALCULATIONS
 1> COMPUTER PERFORMANCE TYPE (Both,Stand,Prop) ..... ProposedOnly
 2> COMPUTER PERFORMANCE CALCULATION (Yes, No) ...... Yes
 3> POINT SYSTEM CALCULATION (Yes, No) .............. No
 4> WATER HEATING CALCULATION (Yes, No) ............. No
 5> HVAC SIZING CALCULATION (Yes, No) ............... No
COMPLIANCE REPORTS
 6> PRINT CF-1R REPORT (Yes, No) .................... No
 7> PRINT MF-1R REPORT (Yes, No) .................... No
 8> PRINT C-2R COMPUTER PERFORMANCE REPORT (Yes,No) . No
 9> PRINT P-2R POINT SYSTEM REPORT (Yes,No,Detailed). No
 10> PRINT FORM-3R REPORT (Yes, No) ................. No
```

FORMATTED INPUT Page 2 FORMAT

```
 12> PRINT HVAC SIZING REPORT (Yes, No, Detailed) ... No
OTHER
 13> PRINT INPUT DATA (Yes, No, Unformatted) ........ No
 14> PRINT TABLE REPORTS (Yes, No, Delimited) ....... Delimited
 15> STANDARD DESIGN INPUT DATA (Save, NoSave) ...... NoSave
```

ZONE

ZONES

```
 #> NUMBER OF ZONES (15 maximum) ..................... 1
```

ZONE 'HOUSE'

```
 1> ZONE NAME ....................................... HOUSE
 2> CONDITIONED (Yes, No) ........................... Yes
 3> ZONE TYPE ....................................... Residence
 4> FLOOR AREA (sf) ................................. 1700
 5> VOLUME (cuft) ................................... 14170
 6> NUMBER OF DWELLING UNITS ........................ 1
HVAC SYSTEM
 7> HEATING SYSTEM NAME ............................. FURN.78
 8> COOLING SYSTEM NAME ............................. AC.10
 9> DUCT SYSTEM NAME ................................ DUCT.4.2
 10> VENTILATION SYSTEM NAME ........................ VENT.2
 11> THERMOSTAT NAME ................................ Setback
HVAC SIZING
 12> NUMBER OF PEOPLE/UNIT (occupants/unit) ......... 4
 13> APPLIANCE GAIN/UNIT  (Btuh/unit) ............... 1200
 14> INFILTRATION CLASS (Tight, Medium, Loose) ...... Medium
```

ZONE TYPES

```
 #> NUMBER OF ZONE TYPES (10 maximum) ................ 5
```

ZONE TYPE 'Residence'

```
 1> ZONE TYPE ....................................... Residence
HEAT CAPACITY
 2> PER ZONE (Btu/F-zone) ........................... 0
 3> PER DWELLING UNIT (Btu/F-unit) .................. 0
 4> PER SF OF FLOOR AREA (Btu/F-sqft) ............... 3.5
INFILTRATION
 5> METHOD (Ach, Ela, Schedule) ..................... Ela
 9> SHIELDING CLASS (1-5) ........................... 4
 10> ELA PER SF OF FLOOR AREA (sqin/sf) ............ 0.07056
INTERNAL HEAT GAIN
 13> PER ZONE (kBtuh/zone) .......................... 0
 14> PER DWELLING UNIT (kBtuh/unit) ................ 20.000
 15> PER SF OF FLOOR AREA (Btuh/sf) ................ 15
 16> SCHEDULE NAME ................................. ResInt
```

ZONE TYPE 'CVCrawlspace'

```
 1> ZONE TYPE ....................................... CVCrawlspace
HEAT CAPACITY
 2> PER ZONE (Btu/F-zone) ........................... 0
 3> PER DWELLING UNIT (Btu/F-unit) .................. 0
 4> PER SF OF FLOOR AREA (Btu/F-sqft) ............... 1.4
INFILTRATION
 5> METHOD (Ach, Ela, Schedule) ..................... Ach
 6> BASE ACH (ac/hr) ................................ 0.22
```

MICROPAS4 v4.01 Date-05/03/95 Program-MENU
Run-1 story post-83 base case Project-SMUD shade tree impact Date-05/03/95

```
 7> TEMP ACH (ac/deg F) ............................ 0
 8> WIND ACH (ac/mph) .............................. 0
INTERNAL HEAT GAIN
 13> PER ZONE (kBtuh/zone) ......................... 0
 14> PER DWELLING UNIT (kBtuh/unit) ................ 0
 15> PER SF OF FLOOR AREA (Btuh/sf) ................ 0
 16> SCHEDULE NAME ................................ ResInt

ZONE TYPE 'Living'

 1> ZONE TYPE ...................................... Living
HEAT CAPACITY
 2> PER ZONE (Btu/F-zone) .......................... 0
 3> PER DWELLING UNIT (Btu/F-unit) ................. 0
 4> PER SF OF FLOOR AREA (Btu/F-sqft) .............. 3.5
INFILTRATION
 5> METHOD (Ach, Ela, Schedule) .................... Ela
 9> SHIELDING CLASS (1-5) .......................... 5
 10> ELA PER SF OF FLOOR AREA (sqin/sf) ............ 0.07056
INTERNAL HEAT GAIN
 13> PER ZONE (kBtuh/zone) ......................... 0
 14> PER DWELLING UNIT (kBtuh/unit) ................ 20.000
 15> PER SF OF FLOOR AREA (Btuh/sf) ................ 15
 16> SCHEDULE NAME ................................ LivInt

ZONE TYPE 'Sleeping'

 1> ZONE TYPE ...................................... Sleeping
HEAT CAPACITY
 2> PER ZONE (Btu/F-zone) .......................... 0
 3> PER DWELLING UNIT (Btu/F-unit) ................. 0
 4> PER SF OF FLOOR AREA (Btu/F-sqft) .............. 3.5
INFILTRATION
 5> METHOD (Ach, Ela, Schedule) .................... Ela
 9> SHIELDING CLASS (1-5) .......................... 5
 10> ELA PER SF OF FLOOR AREA (sqin/sf) ............ 0.07056
INTERNAL HEAT GAIN
 13> PER ZONE (kBtuh/zone) ......................... 0
 14> PER DWELLING UNIT (kBtuh/unit) ................ 0
 15> PER SF OF FLOOR AREA (Btuh/sf) ................ 15
 16> SCHEDULE NAME ................................ SlpInt

ZONE TYPE 'Sunspace'

 1> ZONE TYPE ...................................... Sunspace
HEAT CAPACITY
 2> PER ZONE (Btu/F-zone) .......................... 0
 3> PER DWELLING UNIT (Btu/F-unit) ................. 0
 4> PER SF OF FLOOR AREA (Btu/F-sqft) .............. 3.5
INFILTRATION
 5> METHOD (Ach, Ela, Schedule) .................... Ach
 6> BASE ACH (ac/hr) ............................... 0.50
 7> TEMP ACH (ac/deg F) ............................ 0
 8> WIND ACH (ac/mph) .............................. 0
INTERNAL HEAT GAIN
 13> PER ZONE (kBtuh/zone) ......................... 0
 14> PER DWELLING UNIT (kBtuh/unit) ................ 0
 15> PER SF OF FLOOR AREA (Btuh/sf) ................ 0
 16> SCHEDULE NAME ................................ ResInt
```


OPAQUE

OPAQUE SURFACES

#> NUMBER OF SURFACES (100 maximum) 9

	OPAQUE SURFACE NAME —1—	AREA OR LENGTH —2—	TILT —3—	PLAN AZIMUTH —4—	SOLAR GAINS (Y/N) —5—	OPAQUE CHARAC-TERISTICS —6—	ZONE OR OPAQUE NAME —7—	LOCATION/ COMMENTS —8—
1>	FWALL	343	Vert	Front	.35	WALL.R11	HOUSE	Front Wall
2>	LWALL	343	Vert	Left	.35	WALL.R11	HOUSE	Left Wall
3>	BWALL	343	Vert	Back	.35	WALL.R11	HOUSE	Back Wall
4>	GWALL	183	Vert	Right	.35	WALL.R11	HOUSE	Garage Wall
5>	RWALL	160	Vert	Right	.35	WALL.R11	HOUSE	Right Wall
6>	FDOOR	20	Vert	Front	.35	DOOR	FWALL	Front Door
7>	ROOF	1700	Horz	n/a	.35	ROOF.R30	HOUSE	ATTIC
8>	EEDGE	30	Horz	n/a	No	EDGE.EXT.EXP	HOUSE	Slab Edge
9>	CEDGE	135	Horz	n/a	No	EDGE.EXT.CVR	HOUSE	Slab Edge

OPAQUE CHARACTERISTICS

#> NUMBER OF CHARACTERISTICS (50 maximum) 16

	OPAQUE CHARAC-TERISTIC —1—	OPAQUE SURFACE TYPE —2—	INSUL R-VAL —3—	U-VALUE OR F2-VALUE —4—	FORM3 NAME —5—
1>	WALL.R0	Wall	0	0.386	None
2>	WALL.R11	Wall	11	0.098	None
3>	WALL.R13	Wall	13	0.088	None
4>	WALL.R19	Wall	19	0.065	None
5>	WALL.R21	Wall	21	0.059	None
6>	ROOF.R0	Roof	0	0.306	None
7>	ROOF.R14	Roof	14	0.063	None
8>	ROOF.R19	Roof	19	0.051	None
9>	ROOF.R22	Roof	22	0.042	None
10>	ROOF.R30	Roof	30	0.036	None
11>	ROOF.R38	Roof	38	0.028	None
12>	DOOR	Door	0	0.330	None
13>	FLOOR.R13	Floor	13	0.046	None
14>	FLOOR.R19	Floor	19	0.037	None
15>	EDGE.EXT.EXP	SlabEdge	0	0.90	None
16>	EDGE.EXT.CVR	SlabEdge	0	0.72	None

GLAZING

GLAZING SURFACES

#> NUMBER OF SURFACES (100 maximum) 4

	GLAZING SURFACE NAME —1—	AREA (sf) —2—	TILT —3—	PLAN AZIMUTH —4—	GLAZING CHARAC-TERISTICS —5—	OVERHANG SIDE FIN NAME —6—	EXTERIOR SHADE NAME —7—	ZONE OR OPAQUE NAME —8—
1>	FGLASS	64	Vert	Front	DBL.DIV	FOH	None	FWALL
2>	LGLASS	64	Vert	Left	DBL.DIV	LOH	None	LWALL
3>	BGLASS	64	Vert	Back	DBL.DIV	BOH	None	BWALL
4>	RGLASS	64	Vert	Right	DBL.DIV	ROH	None	RWALL

GLAZING CHARACTERISTICS

#> NUMBER OF CHARACTERISTICS (50 maximum) 2

MICROPAS4 v4.01 Date-05/03/95 Program-MENU
Run-1 story post-83 base case Project-SMUD shade tree impact Date-05/03/95

	GLAZING CHARAC-TERISTICS 1	GLAZING SURFACE TYPE 2	FRAME TYPE 3	VENT OPENING TYPE 4	U-VALUE 5	# OF PANES 6	SC GLASS ONLY 7	SC INT SHADE 8	INTERIOR SHADE DESCRIPTION 9
1>	DBL	Window	Metal	Slider	0.65	2	0.77	0.63	Drapes.Std
2>	DBL.DIV	Window	MetalDiv	Slider	0.65	2	0.88	0.63	Drapes.Std

OVERHANGS AND SIDE FINS

#> NUMBER OF OVERHANGS (50 maximum) 4

	OVERHANG SIDE FIN NAME 1	GLAZ HGHT 2	GLAZ WDTH 3	OVER DPTH 4	OVER HGHT 5	OVER LEFT EXT 6	OVER RGHT EXT 7	LEFT FIN EXT 8	LEFT FIN DPTH 9	LEFT FIN HGHT 10	RGHT FIN EXT 11	RGHT FIN DPTH 12	RGHT FIN HGHT 13
1>	FOH	5	15	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2>	LOH	5	15	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3>	BOH	5	15	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4>	ROH	5	15	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

EXTERIOR SHADING

#> NUMBER OF SHADES (25 maximum) 2

	EXTERIOR SHADE NAME 1	EXTERIOR SHADE DESCRIPTION 2	SC EXTERIOR SHADE 3	WNTR SHAD FAC 4	SUMR SHAD FAC 5	SHADING SCHEDULE 6	SHUT R-VAL 7	SHUT TRAN 8	SHUTTER SCHEDULE 9
1>	EXT.36	SunScreen	0.36	1.00	1.00	None	0.0	0.0	None
2>	C.EXT.44	SunScreen	0.44	1.00	1.00	None	0.0	0.0	None

MASS

MASS SURFACES

#> NUMBER OF SURFACES (50 maximum) 2

	MASS SURFACE NAME 1	AREA (sf) 2	MASS CHARAC-TERISTICS 3	ZONE NAME 4	LOCATION/COMMENTS 5
1>	ESLAB	300	SLAB.EXP	HOUSE	Exposed Slab
2>	CSLAB	1400	SLAB.CVR	HOUSE	Covered Slab

MASS CHARACTERISTICS

#> NUMBER OF CHARACTERISTICS (25 maximum) 2

	MASS CHARAC-TERISTIC 1	MASS TYPE 2	THICK NESS (in) 3	SURF-ACE R-VAL 4	VOLUME HEAT CAP 5	CON-DUCT-IVITY 6	POINT SYS UIMC 7	POINT SYS EMF 8	MASS MODEL 9
1>	SLAB.EXP	SlabOnGrade	3.5	0.0	28	0.98	4.6	n/a	Default
2>	SLAB.CVR	SlabOnGrade	3.5	2.0	28	0.98	1.8	n/a	Default

HVAC

HEATING SYSTEMS

#> NUMBER OF HEATING SYSTEMS (25 maximum) .....

	HEATING SYSTEM NAME 1	HEATING SYSTEM TYPE 2	GAS AFUE 3	HEATPUMP ELECTRIC HSPF 4	HYDRONIC WATER HEATING SYSTEM NAME 5	HEATING CAPACITY 6	HEATING SCHEDULE 7
1>	FURN.78	Furnace	0.78	n/a	None	Unlimited	None

COOLING SYSTEMS

#> NUMBER OF COOLING SYSTEMS (25 maximum) 1

	COOLING SYSTEM NAME 1	COOLING SYSTEM DESCRIPTION 2	SEASONAL EER 3	COOLING CAPACITY 4	COOLING SCHEDULE 5
1>	AC.10	ACSplit	10	Unlimited	None

DUCT SYSTEMS

#> NUMBER OF DUCTS (25 maximum) 1

	DUCT SYSTEM NAME 1	DUCT INSUL R-VALUE 2	HEATING DUCT LOCATION 3	COOLING DUCT LOCATION 4
1>	DUCT.4.2	4.2	Attic	Attic

NATURAL VENTILATION SYSTEMS

#> NUMBER OF VENTILATION SYSTEMS (25 maximum) 2

	VENTILATION SYSTEM NAME 1	VENTILATION TYPE 2	INLET AREA PER ZONE 3	HEIGHT DIFF (ft) 4	PLAN AZM INLET 5	STACK EFF 6	WIND EFF 7	TEMP DIF OR SCHEDULE 8
1>	VENT.8	Standard	0	8.0	Front	1.0	1.0	0
2>	VENT.2	Standard	0	2.0	Front	1.0	1.0	0

THERMOSTATS

#> NUMBER OF THERMOSTATS (25 maximum) 7

	THERMOSTAT NAME 1	WINTER HEATING TEMP 2	WINTER COOLING TEMP 3	WINTER VENT TEMP 4	SUMMER HEATING TEMP 5	SUMMER COOLING TEMP 6	SUMMER VENT TEMP 7
1>	Setback	AutoStat	78	77	60	78	68
2>	NoSetback	ManStat	78	77	60	78	68
3>	AutoCVCVent	0	150	Closed	0	150	Open
4>	ManCVCVent	0	150	Open	0	150	Open
5>	LivingStat	LivHeat	LivCool	77	60	LivCool	68
6>	SleepingStat	SlpHeat	SlpCool	77	60	SlpCool	68
7>	SunspaceStat	0	150	80	0	150	50

WATER HEATING

WATER HEATING SYSTEMS

#> NUMBER OF WATER HEATING SYSTEMS (25 maximum) 1

	WATER HEATING NAME 1	WATER HEATING TYPE 2	HEATER/BOILER SYSTEM NAME 3	# OF HEATERS/BOILERS INSTALLED 4	HYDRONIC SPACE HEATING SYSTEM NAME 5
1>	WH1	DHW	GAS.STOR	1	None

HEATER/BOILER SYSTEMS

MICROPAS4 v4.01 Date-05/03/95 Program-MENU
Run-1 story post-83 base case Project-SMUD shade tree impact Date-05/03/95

#> NUMBER OF HEATER/BOILER SYSTEMS (25 maximum) 1
HEATER/BOILER SYSTEM 'GAS.STOR'

1> HEATER/BOILER SYSTEM NAME ..... GAS.STOR
2> TANK TYPE (Storage, Instantaneous, etc.) ..... Storage
3> HEATER ELEMENT TYPE (Electric, Gas, HeatPump) ... Gas
4> DISTRIBUTION TYPE (Standard, PointOfUse, etc.) .. Standard
5> ENERGY FACTOR 0.53
6> TANK VOLUME (gallons) 45
7> RATED INPUT (Btuh) ..... n/a
10> EXTERNAL BLANKET R-VALUE (hr-sqft-F/Btu) 12
11> INTERNAL INSULATION R-VALUE (hr-sqft-F/Btu) .... n/a
12> RECOVERY EFFICIENCY (fraction) ..... n/a
13> STANDBY LOSS (fraction) ..... n/a
WATER HEATING CREDIT
14> CREDIT TYPE (None, Solar, WoodStove) ..... None

HYDRONIC SPACE HEATING SYSTEMS

#> NUMBER OF HYDRONIC HEATING SYSTEMS (25 maximum) . 0

NOTES

ADDRESSES AND PHONES

#> DISPLAY ADDRESSES AND PHONES (Yes, No) ..... Yes
PROJECT
1> ADDRESS (25 char) ..... SMUD service area
2> CITY (25 char) ..... Sacramento
DESIGNER OR OWNER
3> CONTACT (25 char) ..... Misha Sarkovich
4> FIRM (25 char) ..... SMUD
5> ADDRESS (25 char) .....
6> CITY STATE ZIP (25 char) ..... Sacramento, CA
7> PHONE (25 char) 916/732-6484
8> CALIF LIC NUMBER (25 char) .....

GENERAL NOTES

#> NUMBER OF NOTES (50 maximum) 10

GENERAL NOTES
1

1> Garage wall shade removed 1/13/93
2> Garage shade added back, R38/R19 ins, zone 13 for comparison with
3> SCE runs of Greg. Front door removed. 2/4/93
4> Garage added to N side, Door linked to FWALL, SMUD TOU schedule
5> 2/17/93
6> Square footprint for SMUD sensitivity analysis to tree size,
7> distance and orientation from building. 2/24/95
8> Change input params to agree with SMUD base case (eg. 1700 sq ft)
9> and BSG recommendations to reduce cooling loads 2/27/95
10> None

SCHEDULES

SCHEDULES
#> NUMBER OF SCHEDULES (25 maximum) 11

SCHEDULE 'ResInt'

1> SCHEDULE NAME ..... ResInt
2> SCHEDULE TYPE ..... IntGain
3> SCHEDULE CONTROL ..... Period
4> SCHEDULE MULTIPLIER ..... FullMult
5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ..... ResInt
6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ..... ResInt
7> PERIOD 3 DAILY SCHEDULE NAME ..... ResInt
8> PERIOD 4 DAILY SCHEDULE NAME ..... ResInt
9> PERIOD 5 DAILY SCHEDULE NAME ..... ResInt
10> PERIOD 6 DAILY SCHEDULE NAME ..... ResInt
11> PERIOD 7 DAILY SCHEDULE NAME ..... ResInt
12> PERIOD 8 DAILY SCHEDULE NAME ..... ResInt
13> PERIOD 9 DAILY SCHEDULE NAME ..... ResInt
14> PERIOD 10 DAILY SCHEDULE NAME ..... ResInt
15> PERIOD 11 DAILY SCHEDULE NAME ..... ResInt
16> PERIOD 12 DAILY SCHEDULE NAME ..... ResInt

SCHEDULE 'AutoStat'

1> SCHEDULE NAME ..... AutoStat
2> SCHEDULE TYPE ..... Thermostat
3> SCHEDULE CONTROL ..... Period
4> SCHEDULE MULTIPLIER ..... None
5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ..... AutoStat
6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ..... AutoStat
7> PERIOD 3 DAILY SCHEDULE NAME ..... AutoStat
8> PERIOD 4 DAILY SCHEDULE NAME ..... AutoStat
9> PERIOD 5 DAILY SCHEDULE NAME ..... AutoStat
10> PERIOD 6 DAILY SCHEDULE NAME ..... AutoStat
11> PERIOD 7 DAILY SCHEDULE NAME ..... AutoStat
12> PERIOD 8 DAILY SCHEDULE NAME ..... AutoStat
13> PERIOD 9 DAILY SCHEDULE NAME ..... AutoStat
14> PERIOD 10 DAILY SCHEDULE NAME ..... AutoStat
15> PERIOD 11 DAILY SCHEDULE NAME ..... AutoStat
16> PERIOD 12 DAILY SCHEDULE NAME ..... AutoStat

SCHEDULE 'ManStat'

1> SCHEDULE NAME ..... ManStat
2> SCHEDULE TYPE ..... Thermostat
3> SCHEDULE CONTROL ..... Period
4> SCHEDULE MULTIPLIER ..... None
5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ..... ManStat
6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ..... ManStat
7> PERIOD 3 DAILY SCHEDULE NAME ..... ManStat
8> PERIOD 4 DAILY SCHEDULE NAME ..... ManStat
9> PERIOD 5 DAILY SCHEDULE NAME ..... ManStat
10> PERIOD 6 DAILY SCHEDULE NAME ..... ManStat
11> PERIOD 7 DAILY SCHEDULE NAME ..... ManStat
12> PERIOD 8 DAILY SCHEDULE NAME ..... ManStat
13> PERIOD 9 DAILY SCHEDULE NAME ..... ManStat
14> PERIOD 10 DAILY SCHEDULE NAME ..... ManStat
15> PERIOD 11 DAILY SCHEDULE NAME ..... ManStat
16> PERIOD 12 DAILY SCHEDULE NAME ..... ManStat

SCHEDULE 'LivInt'

1> SCHEDULE NAME ..... LivInt

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MICROPAS4 v4.01  Date-05/03/95  Program-MENU
Run-1 story post-83 base case  Project-SMUD shade tree impact  Date-05/03/95

 2> SCHEDULE TYPE ..................................... IntGain
 3> SCHEDULE CONTROL ................................... Period
 4> SCHEDULE MULTIPLIER ................................ None
 5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........... LivInt
 6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........... LivInt
 7> PERIOD 3 DAILY SCHEDULE NAME ..................... LivInt
 8> PERIOD 4 DAILY SCHEDULE NAME ..................... LivInt
 9> PERIOD 5 DAILY SCHEDULE NAME ..................... LivInt
 10> PERIOD 6 DAILY SCHEDULE NAME .................... LivInt
 11> PERIOD 7 DAILY SCHEDULE NAME .................... LivInt
 12> PERIOD 8 DAILY SCHEDULE NAME .................... LivInt
 13> PERIOD 9 DAILY SCHEDULE NAME .................... LivInt
 14> PERIOD 10 DAILY SCHEDULE NAME ................... LivInt
 15> PERIOD 11 DAILY SCHEDULE NAME ................... LivInt
 16> PERIOD 12 DAILY SCHEDULE NAME ................... LivInt

SCHEDULE 'SlpInt'

 1> SCHEDULE NAME ..................................... SlpInt
 2> SCHEDULE TYPE ..................................... IntGain
 3> SCHEDULE CONTROL ................................... Period
 4> SCHEDULE MULTIPLIER ................................ None
 5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........... SlpInt
 6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........... SlpInt
 7> PERIOD 3 DAILY SCHEDULE NAME ..................... SlpInt
 8> PERIOD 4 DAILY SCHEDULE NAME ..................... SlpInt
 9> PERIOD 5 DAILY SCHEDULE NAME ..................... SlpInt
 10> PERIOD 6 DAILY SCHEDULE NAME .................... SlpInt
 11> PERIOD 7 DAILY SCHEDULE NAME .................... SlpInt
 12> PERIOD 8 DAILY SCHEDULE NAME .................... SlpInt
 13> PERIOD 9 DAILY SCHEDULE NAME .................... SlpInt
 14> PERIOD 10 DAILY SCHEDULE NAME ................... SlpInt
 15> PERIOD 11 DAILY SCHEDULE NAME ................... SlpInt
 16> PERIOD 12 DAILY SCHEDULE NAME ................... SlpInt

SCHEDULE 'LivHeat'

 1> SCHEDULE NAME ..................................... LivHeat
 2> SCHEDULE TYPE ..................................... Thermostat
 3> SCHEDULE CONTROL ................................... Period
 4> SCHEDULE MULTIPLIER ................................ None
 5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........... LivHeat
 6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........... LivHeat
 7> PERIOD 3 DAILY SCHEDULE NAME ..................... LivHeat
 8> PERIOD 4 DAILY SCHEDULE NAME ..................... LivHeat
 9> PERIOD 5 DAILY SCHEDULE NAME ..................... LivHeat
 10> PERIOD 6 DAILY SCHEDULE NAME .................... LivHeat
 11> PERIOD 7 DAILY SCHEDULE NAME .................... LivHeat
 12> PERIOD 8 DAILY SCHEDULE NAME .................... LivHeat
 13> PERIOD 9 DAILY SCHEDULE NAME .................... LivHeat
 14> PERIOD 10 DAILY SCHEDULE NAME ................... LivHeat
 15> PERIOD 11 DAILY SCHEDULE NAME ................... LivHeat
 16> PERIOD 12 DAILY SCHEDULE NAME ................... LivHeat

SCHEDULE 'LivCool'

 1> SCHEDULE NAME ..................................... LivCool
 2> SCHEDULE TYPE ..................................... Thermostat
 3> SCHEDULE CONTROL ................................... Period
```



```
 4> SCHEDULE MULTIPLIER ................................ None
 5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........... LivCool
 6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........... LivCool
 7> PERIOD 3 DAILY SCHEDULE NAME ..................... LivCool
 8> PERIOD 4 DAILY SCHEDULE NAME ..................... LivCool
 9> PERIOD 5 DAILY SCHEDULE NAME ..................... LivCool
 10> PERIOD 6 DAILY SCHEDULE NAME .................... LivCool
 11> PERIOD 7 DAILY SCHEDULE NAME .................... LivCool
 12> PERIOD 8 DAILY SCHEDULE NAME .................... LivCool
 13> PERIOD 9 DAILY SCHEDULE NAME .................... LivCool
 14> PERIOD 10 DAILY SCHEDULE NAME ................... LivCool
 15> PERIOD 11 DAILY SCHEDULE NAME ................... LivCool
 16> PERIOD 12 DAILY SCHEDULE NAME ................... LivCool

SCHEDULE 'SlpHeat'

 1> SCHEDULE NAME ..................................... SlpHeat
 2> SCHEDULE TYPE ..................................... Thermostat
 3> SCHEDULE CONTROL ................................... Period
 4> SCHEDULE MULTIPLIER ................................ None
 5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........... SlpHeat
 6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........... SlpHeat
 7> PERIOD 3 DAILY SCHEDULE NAME ..................... SlpHeat
 8> PERIOD 4 DAILY SCHEDULE NAME ..................... SlpHeat
 9> PERIOD 5 DAILY SCHEDULE NAME ..................... SlpHeat
 10> PERIOD 6 DAILY SCHEDULE NAME .................... SlpHeat
 11> PERIOD 7 DAILY SCHEDULE NAME .................... SlpHeat
 12> PERIOD 8 DAILY SCHEDULE NAME .................... SlpHeat
 13> PERIOD 9 DAILY SCHEDULE NAME .................... SlpHeat
 14> PERIOD 10 DAILY SCHEDULE NAME ................... SlpHeat
 15> PERIOD 11 DAILY SCHEDULE NAME ................... SlpHeat
 16> PERIOD 12 DAILY SCHEDULE NAME ................... SlpHeat

SCHEDULE 'SlpCool'

 1> SCHEDULE NAME ..................................... SlpCool
 2> SCHEDULE TYPE ..................................... Thermostat
 3> SCHEDULE CONTROL ................................... Period
 4> SCHEDULE MULTIPLIER ................................ None
 5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........... SlpCool
 6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........... SlpCool
 7> PERIOD 3 DAILY SCHEDULE NAME ..................... SlpCool
 8> PERIOD 4 DAILY SCHEDULE NAME ..................... SlpCool
 9> PERIOD 5 DAILY SCHEDULE NAME ..................... SlpCool
 10> PERIOD 6 DAILY SCHEDULE NAME .................... SlpCool
 11> PERIOD 7 DAILY SCHEDULE NAME .................... SlpCool
 12> PERIOD 8 DAILY SCHEDULE NAME .................... SlpCool
 13> PERIOD 9 DAILY SCHEDULE NAME .................... SlpCool
 14> PERIOD 10 DAILY SCHEDULE NAME ................... SlpCool
 15> PERIOD 11 DAILY SCHEDULE NAME ................... SlpCool
 16> PERIOD 12 DAILY SCHEDULE NAME ................... SlpCool

SCHEDULE 'TOU'

 1> SCHEDULE NAME ..................................... TOU
 2> SCHEDULE TYPE ..................................... TimeOfUse
 3> SCHEDULE CONTROL ................................... Period
 4> SCHEDULE MULTIPLIER ................................ None
 5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........... WIN
 6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........... WIN
 7> PERIOD 3 DAILY SCHEDULE NAME ..................... WIN
 8> PERIOD 4 DAILY SCHEDULE NAME ..................... WIN
 9> PERIOD 5 DAILY SCHEDULE NAME ..................... SUM
```

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MICROPAS4 v4.01  Date-05/03/95  Program-MENU
Run-1 story post-83 base case  Project-SMUD shade tree impact  Date-05/03/95
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```
 10> PERIOD 6 DAILY SCHEDULE NAME ................... SUM
 11> PERIOD 7 DAILY SCHEDULE NAME ................... SUM
 12> PERIOD 8 DAILY SCHEDULE NAME ................... SUM
 13> PERIOD 9 DAILY SCHEDULE NAME ................... SUM
 14> PERIOD 10 DAILY SCHEDULE NAME .................. SUM
 15> PERIOD 11 DAILY SCHEDULE NAME .................. WIN
 16> PERIOD 12 DAILY SCHEDULE NAME .................. WIN

SCHEDULE 'FullMult'

  1> SCHEDULE NAME ................................. FullMult
  2> SCHEDULE TYPE ................................. Multiplier
  3> SCHEDULE CONTROL .............................. Period
  4> SCHEDULE MULTIPLIER ........................... None
  5> PERIOD 1 OR WINTER DAILY SCHEDULE NAME ........ 1.19
  6> PERIOD 2 OR SUMMER DAILY SCHEDULE NAME ........ 1.11
  7> PERIOD 3 DAILY SCHEDULE NAME ................... 1.02
  8> PERIOD 4 DAILY SCHEDULE NAME ................... 0.93
  9> PERIOD 5 DAILY SCHEDULE NAME ................... 0.84
 10> PERIOD 6 DAILY SCHEDULE NAME ................... 0.80
 11> PERIOD 7 DAILY SCHEDULE NAME ................... 0.82
 12> PERIOD 8 DAILY SCHEDULE NAME ................... 0.88
 13> PERIOD 9 DAILY SCHEDULE NAME ................... 0.98
 14> PERIOD 10 DAILY SCHEDULE NAME .................. 1.07
 15> PERIOD 11 DAILY SCHEDULE NAME .................. 1.16
 16> PERIOD 12 DAILY SCHEDULE NAME .................. 1.21

DAILY SCHEDULES

 #> NUMBER OF DAILY SCHEDULES (25 maximum) ......... 11

DAILY SCHEDULE 'ResInt'

  1> DAILY SCHEDULE NAME ........................... ResInt
  2> SCHEDULE TYPE ................................. IntGain
  3> SUNDAY HOURLY SCHEDULE NAME ................... ResInt
  4> MONDAY HOURLY SCHEDULE NAME ................... ResInt
  5> TUESDAY HOURLY SCHEDULE NAME .................. ResInt
  6> WEDNESDAY HOURLY SCHEDULE NAME ................ ResInt
  7> THURSDAY HOURLY SCHEDULE NAME ................. ResInt
  8> FRIDAY HOURLY SCHEDULE NAME ................... ResInt
  9> SATURDAY HOURLY SCHEDULE NAME ................. ResInt
 10> HOLIDAY HOURLY SCHEDULE NAME .................. ResInt

DAILY SCHEDULE 'AutoStat'

  1> DAILY SCHEDULE NAME ........................... AutoStat
  2> SCHEDULE TYPE ................................. Thermostat
  3> SUNDAY HOURLY SCHEDULE NAME ................... AutoStat
  4> MONDAY HOURLY SCHEDULE NAME ................... AutoStat
  5> TUESDAY HOURLY SCHEDULE NAME .................. AutoStat
  6> WEDNESDAY HOURLY SCHEDULE NAME ................ AutoStat
  7> THURSDAY HOURLY SCHEDULE NAME ................. AutoStat
  8> FRIDAY HOURLY SCHEDULE NAME ................... AutoStat
  9> SATURDAY HOURLY SCHEDULE NAME ................. AutoStat
 10> HOLIDAY HOURLY SCHEDULE NAME .................. AutoStat

DAILY SCHEDULE 'ManStat'
```



```
  1> DAILY SCHEDULE NAME ........................... ManStat
  2> SCHEDULE TYPE ................................. Thermostat
  3> SUNDAY HOURLY SCHEDULE NAME ................... ManStat
  4> MONDAY HOURLY SCHEDULE NAME ................... ManStat
  5> TUESDAY HOURLY SCHEDULE NAME .................. ManStat
  6> WEDNESDAY HOURLY SCHEDULE NAME ................ ManStat
  7> THURSDAY HOURLY SCHEDULE NAME ................. ManStat
  8> FRIDAY HOURLY SCHEDULE NAME ................... ManStat
  9> SATURDAY HOURLY SCHEDULE NAME ................. ManStat
 10> HOLIDAY HOURLY SCHEDULE NAME .................. ManStat

DAILY SCHEDULE 'LivInt'

  1> DAILY SCHEDULE NAME ........................... LivInt
  2> SCHEDULE TYPE ................................. IntGain
  3> SUNDAY HOURLY SCHEDULE NAME ................... LivInt
  4> MONDAY HOURLY SCHEDULE NAME ................... LivInt
  5> TUESDAY HOURLY SCHEDULE NAME .................. LivInt
  6> WEDNESDAY HOURLY SCHEDULE NAME ................ LivInt
  7> THURSDAY HOURLY SCHEDULE NAME ................. LivInt
  8> FRIDAY HOURLY SCHEDULE NAME ................... LivInt
  9> SATURDAY HOURLY SCHEDULE NAME ................. LivInt
 10> HOLIDAY HOURLY SCHEDULE NAME .................. LivInt

DAILY SCHEDULE 'SlpInt'

  1> DAILY SCHEDULE NAME ........................... SlpInt
  2> SCHEDULE TYPE ................................. IntGain
  3> SUNDAY HOURLY SCHEDULE NAME ................... SlpInt
  4> MONDAY HOURLY SCHEDULE NAME ................... SlpInt
  5> TUESDAY HOURLY SCHEDULE NAME .................. SlpInt
  6> WEDNESDAY HOURLY SCHEDULE NAME ................ SlpInt
  7> THURSDAY HOURLY SCHEDULE NAME ................. SlpInt
  8> FRIDAY HOURLY SCHEDULE NAME ................... SlpInt
  9> SATURDAY HOURLY SCHEDULE NAME ................. SlpInt
 10> HOLIDAY HOURLY SCHEDULE NAME .................. SlpInt

DAILY SCHEDULE 'LivHeat'

  1> DAILY SCHEDULE NAME ........................... LivHeat
  2> SCHEDULE TYPE ................................. Thermostat
  3> SUNDAY HOURLY SCHEDULE NAME ................... LivHeat
  4> MONDAY HOURLY SCHEDULE NAME ................... LivHeat
  5> TUESDAY HOURLY SCHEDULE NAME .................. LivHeat
  6> WEDNESDAY HOURLY SCHEDULE NAME ................ LivHeat
  7> THURSDAY HOURLY SCHEDULE NAME ................. LivHeat
  8> FRIDAY HOURLY SCHEDULE NAME ................... LivHeat
  9> SATURDAY HOURLY SCHEDULE NAME ................. LivHeat
 10> HOLIDAY HOURLY SCHEDULE NAME .................. LivHeat

DAILY SCHEDULE 'LivCool'

  1> DAILY SCHEDULE NAME ........................... LivCool
  2> SCHEDULE TYPE ................................. Thermostat
  3> SUNDAY HOURLY SCHEDULE NAME ................... LivCool
  4> MONDAY HOURLY SCHEDULE NAME ................... LivCool
  5> TUESDAY HOURLY SCHEDULE NAME .................. LivCool
  6> WEDNESDAY HOURLY SCHEDULE NAME ................ LivCool
  7> THURSDAY HOURLY SCHEDULE NAME ................. LivCool
  8> FRIDAY HOURLY SCHEDULE NAME ................... LivCool
  9> SATURDAY HOURLY SCHEDULE NAME ................. LivCool
 10> HOLIDAY HOURLY SCHEDULE NAME .................. LivCool
```

MICROPAS4 v4.01 Date-05/03/95 Program-MENU
Run-1 story post-83 base case Project-SMUD shade tree impact Date-05/03/95

DAILY SCHEDULE 'SlpHeat'

1> DAILY SCHEDULE NAME ..... SlpHeat
2> SCHEDULE TYPE ..... Thermostat
3> SUNDAY HOURLY SCHEDULE NAME ..... SlpHeat
4> MONDAY HOURLY SCHEDULE NAME ..... SlpHeat
5> TUESDAY HOURLY SCHEDULE NAME ..... SlpHeat
6> WEDNESDAY HOURLY SCHEDULE NAME ..... SlpHeat
7> THURSDAY HOURLY SCHEDULE NAME ..... SlpHeat
8> FRIDAY HOURLY SCHEDULE NAME ..... SlpHeat
9> SATURDAY HOURLY SCHEDULE NAME ..... SlpHeat
10> HOLIDAY HOURLY SCHEDULE NAME ..... SlpHeat

DAILY SCHEDULE 'SlpCool'

1> DAILY SCHEDULE NAME ..... SlpCool
2> SCHEDULE TYPE ..... Thermostat
3> SUNDAY HOURLY SCHEDULE NAME ..... SlpCool
4> MONDAY HOURLY SCHEDULE NAME ..... SlpCool
5> TUESDAY HOURLY SCHEDULE NAME ..... SlpCool
6> WEDNESDAY HOURLY SCHEDULE NAME ..... SlpCool
7> THURSDAY HOURLY SCHEDULE NAME ..... SlpCool
8> FRIDAY HOURLY SCHEDULE NAME ..... SlpCool
9> SATURDAY HOURLY SCHEDULE NAME ..... SlpCool
10> HOLIDAY HOURLY SCHEDULE NAME ..... SlpCool

DAILY SCHEDULE 'SUM'

1> DAILY SCHEDULE NAME ..... SUM
2> SCHEDULE TYPE ..... TimeOfUse
3> SUNDAY HOURLY SCHEDULE NAME ..... BASE
4> MONDAY HOURLY SCHEDULE NAME ..... SUMPEAK
5> TUESDAY HOURLY SCHEDULE NAME ..... SUMPEAK
6> WEDNESDAY HOURLY SCHEDULE NAME ..... SUMPEAK
7> THURSDAY HOURLY SCHEDULE NAME ..... SUMPEAK
8> FRIDAY HOURLY SCHEDULE NAME ..... SUMPEAK
9> SATURDAY HOURLY SCHEDULE NAME ..... BASE
10> HOLIDAY HOURLY SCHEDULE NAME ..... BASE

DAILY SCHEDULE 'WIN'

1> DAILY SCHEDULE NAME ..... WIN
2> SCHEDULE TYPE ..... TimeOfUse
3> SUNDAY HOURLY SCHEDULE NAME ..... BASE
4> MONDAY HOURLY SCHEDULE NAME ..... WINPEAK
5> TUESDAY HOURLY SCHEDULE NAME ..... WINPEAK
6> WEDNESDAY HOURLY SCHEDULE NAME ..... WINPEAK
7> THURSDAY HOURLY SCHEDULE NAME ..... WINPEAK
8> FRIDAY HOURLY SCHEDULE NAME ..... WINPEAK
9> SATURDAY HOURLY SCHEDULE NAME ..... BASE
10> HOLIDAY HOURLY SCHEDULE NAME ..... BASE

HOURLY SCHEDULES

#> NUMBER OF HOURLY SCHEDULES (25 maximum) 12

HOURLY SCHEDULE 'ResInt'

1> SCHEDULE NAME ..... ResInt
2> SCHEDULE TYPE ..... IntGain

3> HOUR 01 ..... 0.024
4> HOUR 02 ..... 0.022
5> HOUR 03 ..... 0.021
6> HOUR 04 ..... 0.021
7> HOUR 05 ..... 0.021
8> HOUR 06 ..... 0.026
9> HOUR 07 ..... 0.038
10> HOUR 08 ..... 0.059
11> HOUR 09 ..... 0.056
12> HOUR 10 ..... 0.060
13> HOUR 11 ..... 0.059
14> HOUR 12 ..... 0.046
15> HOUR 13 ..... 0.045
16> HOUR 14 ..... 0.030
17> HOUR 15 ..... 0.028
18> HOUR 16 ..... 0.031
19> HOUR 17 ..... 0.057
20> HOUR 18 ..... 0.064
21> HOUR 19 ..... 0.064
22> HOUR 20 ..... 0.052
23> HOUR 21 ..... 0.050
24> HOUR 22 ..... 0.055
25> HOUR 23 ..... 0.044
26> HOUR 24 ..... 0.027

HOURLY SCHEDULE 'AutoStat'

1> SCHEDULE NAME ..... AutoStat
2> SCHEDULE TYPE ..... Thermostat
3> HOUR 01 60
4> HOUR 02 60
5> HOUR 03 60
6> HOUR 04 60
7> HOUR 05 60
8> HOUR 06 60
9> HOUR 07 60
10> HOUR 08 68
11> HOUR 09 68
12> HOUR 10 68
13> HOUR 11 68
14> HOUR 12 68
15> HOUR 13 68
16> HOUR 14 68
17> HOUR 15 68
18> HOUR 16 68
19> HOUR 17 68
20> HOUR 18 68
21> HOUR 19 68
22> HOUR 20 68
23> HOUR 21 68
24> HOUR 22 68
25> HOUR 23 68
26> HOUR 24 60

HOURLY SCHEDULE 'ManStat'

1> SCHEDULE NAME ..... ManStat
2> SCHEDULE TYPE ..... Thermostat
3> HOUR 01 66
4> HOUR 02 66
5> HOUR 03 66
6> HOUR 04 66
7> HOUR 05 66

MICROPAS4 v4.01 Date-05/03/95 Program-MENU
Run-1 story post-83 base case Project-SMUD shade tree impact Date-05/03/95

```
 8> HOUR 06 ........................................ 66
 9> HOUR 07 ........................................ 66
10> HOUR 08 ........................................ 68
11> HOUR 09 ........................................ 68
12> HOUR 10 ........................................ 68
13> HOUR 11 ........................................ 68
14> HOUR 12 ........................................ 68
15> HOUR 13 ........................................ 68
16> HOUR 14 ........................................ 68
17> HOUR 15 ........................................ 68
18> HOUR 16 ........................................ 68
19> HOUR 17 ........................................ 68
20> HOUR 18 ........................................ 68
21> HOUR 19 ........................................ 68
22> HOUR 20 ........................................ 68
23> HOUR 21 ........................................ 68
24> HOUR 22 ........................................ 68
25> HOUR 23 ........................................ 68
26> HOUR 24 ........................................ 66
```

HOURLY SCHEDULE 'LivInt'

```
 1> SCHEDULE NAME ................................ LivInt
 2> SCHEDULE TYPE ................................ IntGain
 3> HOUR 01 ......................................... 0.0161
 4> HOUR 02 ......................................... 0.0148
 5> HOUR 03 ......................................... 0.0114
 6> HOUR 04 ......................................... 0.0113
 7> HOUR 05 ......................................... 0.0121
 8> HOUR 06 ......................................... 0.0146
 9> HOUR 07 ......................................... 0.0277
10> HOUR 08 ......................................... 0.0530
11> HOUR 09 ......................................... 0.0633
12> HOUR 10 ......................................... 0.0686
13> HOUR 11 ......................................... 0.0638
14> HOUR 12 ......................................... 0.0500
15> HOUR 13 ......................................... 0.0484
16> HOUR 14 ......................................... 0.0315
17> HOUR 15 ......................................... 0.0294
18> HOUR 16 ......................................... 0.0341
19> HOUR 17 ......................................... 0.0619
20> HOUR 18 ......................................... 0.0718
21> HOUR 19 ......................................... 0.0724
22> HOUR 20 ......................................... 0.0596
23> HOUR 21 ......................................... 0.0500
24> HOUR 22 ......................................... 0.0620
25> HOUR 23 ......................................... 0.0438
26> HOUR 24 ......................................... 0.0235
```

HOURLY SCHEDULE 'SlpInt'

```
 1> SCHEDULE NAME ................................ SlpInt
 2> SCHEDULE TYPE ................................ IntGain
 3> HOUR 01 ......................................... 0.0438
 4> HOUR 02 ......................................... 0.0402
 5> HOUR 03 ......................................... 0.0450
 6> HOUR 04 ......................................... 0.0450
 7> HOUR 05 ......................................... 0.0432
 8> HOUR 06 ......................................... 0.0546
```



```
 9> HOUR 07 ......................................... 0.0639
10> HOUR 08 ......................................... 0.0740
11> HOUR 09 ......................................... 0.0376
12> HOUR 10 ......................................... 0.0385
13> HOUR 11 ......................................... 0.0470
14> HOUR 12 ......................................... 0.0361
15> HOUR 13 ......................................... 0.0365
16> HOUR 14 ......................................... 0.0263
17> HOUR 15 ......................................... 0.0246
18> HOUR 16 ......................................... 0.0232
19> HOUR 17 ......................................... 0.0447
20> HOUR 18 ......................................... 0.0445
21> HOUR 19 ......................................... 0.0429
22> HOUR 20 ......................................... 0.0330
23> HOUR 21 ......................................... 0.0375
24> HOUR 22 ......................................... 0.0375
25> HOUR 23 ......................................... 0.0445
26> HOUR 24 ......................................... 0.0359
```

HOURLY SCHEDULE 'LivHeat'

```
 1> SCHEDULE NAME ................................ LivHeat
 2> SCHEDULE TYPE ................................ Thermostat
 3> HOUR 01 ......................................... 60
 4> HOUR 02 ......................................... 60
 5> HOUR 03 ......................................... 60
 6> HOUR 04 ......................................... 60
 7> HOUR 05 ......................................... 60
 8> HOUR 06 ......................................... 60
 9> HOUR 07 ......................................... 60
10> HOUR 08 ......................................... 68
11> HOUR 09 ......................................... 68
12> HOUR 10 ......................................... 68
13> HOUR 11 ......................................... 68
14> HOUR 12 ......................................... 68
15> HOUR 13 ......................................... 68
16> HOUR 14 ......................................... 68
17> HOUR 15 ......................................... 68
18> HOUR 16 ......................................... 68
19> HOUR 17 ......................................... 68
20> HOUR 18 ......................................... 68
21> HOUR 19 ......................................... 68
22> HOUR 20 ......................................... 68
23> HOUR 21 ......................................... 68
24> HOUR 22 ......................................... 68
25> HOUR 23 ......................................... 68
26> HOUR 24 ......................................... 60
```

HOURLY SCHEDULE 'LivCool'

```
 1> SCHEDULE NAME ................................ LivCool
 2> SCHEDULE TYPE ................................ Thermostat
 3> HOUR 01 ......................................... 83
 4> HOUR 02 ......................................... 83
 5> HOUR 03 ......................................... 83
 6> HOUR 04 ......................................... 83
 7> HOUR 05 ......................................... 83
 8> HOUR 06 ......................................... 83
 9> HOUR 07 ......................................... 83
10> HOUR 08 ......................................... 78
11> HOUR 09 ......................................... 78
12> HOUR 10 ......................................... 78
13> HOUR 11 ......................................... 78
```

MICROPAS4 v4.01 Date-05/03/95 Program-MENU
Run-1 story post-83 base case Project-SMUD shade tree impact Date-05/03/95

14> HOUR 12 78
15> HOUR 13 78
16> HOUR 14 78
17> HOUR 15 78
18> HOUR 16 78
19> HOUR 17 78
20> HOUR 18 78
21> HOUR 19 78
22> HOUR 20 78
23> HOUR 21 78
24> HOUR 22 78
25> HOUR 23 78
26> HOUR 24 83

HOURLY SCHEDULE 'SlpHeat'

1> SCHEDULE NAME ..... SlpHeat
2> SCHEDULE TYPE ..... Thermostat
3> HOUR 01 60
4> HOUR 02 60
5> HOUR 03 60
6> HOUR 04 60
7> HOUR 05 60
8> HOUR 06 60
9> HOUR 07 60
10> HOUR 08 68
11> HOUR 09 60
12> HOUR 10 60
13> HOUR 11 60
14> HOUR 12 60
15> HOUR 13 60
16> HOUR 14 60
17> HOUR 15 60
18> HOUR 16 60
19> HOUR 17 60
20> HOUR 18 60
21> HOUR 19 60
22> HOUR 20 60
23> HOUR 21 60
24> HOUR 22 68
25> HOUR 23 68
26> HOUR 24 60

HOURLY SCHEDULE 'SlpCool'

1> SCHEDULE NAME ..... SlpCool
2> SCHEDULE TYPE ..... Thermostat
3> HOUR 01 78
4> HOUR 02 78
5> HOUR 03 78
6> HOUR 04 78
7> HOUR 05 78
8> HOUR 06 78
9> HOUR 07 78
10> HOUR 08 83
11> HOUR 09 83
12> HOUR 10 83
13> HOUR 11 83
14> HOUR 12 83

15> HOUR 13 83
16> HOUR 14 83
17> HOUR 15 83
18> HOUR 16 83
19> HOUR 17 83
20> HOUR 18 83
21> HOUR 19 83
22> HOUR 20 83
23> HOUR 21 83
24> HOUR 22 78
25> HOUR 23 78
26> HOUR 24 78

HOURLY SCHEDULE 'SUMPEAK'

1> SCHEDULE NAME ..... SUMPEAK
2> SCHEDULE TYPE ..... TimeOfUse
3> HOUR 01 ..... OffPeak
4> HOUR 02 ..... OffPeak
5> HOUR 03 ..... OffPeak
6> HOUR 04 ..... OffPeak
7> HOUR 05 ..... OffPeak
8> HOUR 06 ..... OffPeak
9> HOUR 07 ..... OffPeak
10> HOUR 08 ..... OffPeak
11> HOUR 09 ..... OffPeak
12> HOUR 10 ..... OffPeak
13> HOUR 11 ..... OffPeak
14> HOUR 12 ..... OnPeak
15> HOUR 13 ..... OnPeak
16> HOUR 14 ..... OnPeak
17> HOUR 15 ..... OnPeak
18> HOUR 16 ..... OnPeak
19> HOUR 17 ..... OnPeak
20> HOUR 18 ..... OnPeak
21> HOUR 19 ..... OffPeak
22> HOUR 20 ..... OffPeak
23> HOUR 21 ..... OffPeak
24> HOUR 22 ..... OffPeak
25> HOUR 23 ..... OffPeak
26> HOUR 24 ..... OffPeak

HOURLY SCHEDULE 'WINPEAK'

1> SCHEDULE NAME ..... WINPEAK
2> SCHEDULE TYPE ..... TimeOfUse
3> HOUR 01 ..... OffPeak
4> HOUR 02 ..... OffPeak
5> HOUR 03 ..... OffPeak
6> HOUR 04 ..... OffPeak
7> HOUR 05 ..... OffPeak
8> HOUR 06 ..... OffPeak
9> HOUR 07 ..... OffPeak
10> HOUR 08 ..... OffPeak
11> HOUR 09 ..... OffPeak
12> HOUR 10 ..... OffPeak
13> HOUR 11 ..... OffPeak
14> HOUR 12 ..... OnPeak
15> HOUR 13 ..... OnPeak
16> HOUR 14 ..... OnPeak
17> HOUR 15 ..... OnPeak
18> HOUR 16 ..... OnPeak
19> HOUR 17 ..... OnPeak

NICROPAS4 v4.01 Date-05/03/95 Program-MENU
Run-1 story post-83 base case Project-SMUD shade tree impact Date-05/03/95

20> HOUR 18 ..... OnPeak
21> HOUR 19 ..... OffPeak
22> HOUR 20 ..... OffPeak
23> HOUR 21 ..... OffPeak
24> HOUR 22 ..... OffPeak
25> HOUR 23 ..... OffPeak
26> HOUR 24 ..... OffPeak

HOURLY SCHEDULE 'BASE'

1> SCHEDULE NAME ..... BASE
2> SCHEDULE TYPE ..... TimeOfUse
3> HOUR 01 ..... OffPeak
4> HOUR 02 ..... OffPeak
5> HOUR 03 ..... OffPeak
6> HOUR 04 ..... OffPeak
7> HOUR 05 ..... OffPeak
8> HOUR 06 ..... OffPeak
9> HOUR 07 ..... OffPeak
10> HOUR 08 ..... OffPeak
11> HOUR 09 ..... OffPeak
12> HOUR 10 ..... OffPeak
13> HOUR 11 ..... OffPeak
14> HOUR 12 ..... OffPeak
15> HOUR 13 ..... OffPeak
16> HOUR 14 ..... OffPeak
17> HOUR 15 ..... OffPeak
18> HOUR 16 ..... OffPeak
19> HOUR 17 ..... OffPeak
20> HOUR 18 ..... OffPeak
21> HOUR 19 ..... OffPeak
22> HOUR 20 ..... OffPeak
23> HOUR 21 ..... OffPeak
24> HOUR 22 ..... OffPeak
25> HOUR 23 ..... OffPeak
26> HOUR 24 ..... OffPeak

MISCELLANEOUS

TABLE REPORT SPECIFICATIONS

#> NUMBER OF TABLES (100 maximum) 9

	TABLE TYPE 1	TABLE TIMESCALE 2	PERIOD TO REPORT 3	DAYS TO REPORT 4
1>	Source	Yearly	None	None
2>	Peak	Yearly	None	None
3>	Load	Hourly	August	7
4>	HeatFlow	Hourly	August	7
5>	TimeOfUse	Period	None	None
6>	HoursOfUse	Period	None	None
7>	Energy	Period	None	None
8>	Bin	None	None	None
9>	Ambient	None	None	None

SIMULATION CONTROL

#> NUMBER OF SIMULATION SEASONS (12 maximum) 12

	SEASON NAME 1	SIMULATE SEASON 2
1>	January	Yes
2>	February	Yes
3>	March	Yes
4>	April	Yes
5>	May	Yes
6>	June	Yes
7>	July	Yes
8>	August	Yes
9>	September	Yes
10>	October	Yes
11>	November	Yes
12>	December	Yes

OPTIONS

GLAZING
1> GLAZING OBSTRUCTION FACTOR (fraction) 0.675
2> USE SINGLE PANE TAUS (Yes, No) ..... Yes
AIR FILM ADJUSTMENT
3> ADJUST AIR FILM R-VALUE (Yes, No) ..... Yes
4> AIR FILM R-VALUE BEFORE ADJUSTMENT 0.17
5> AIR FILM R-VALUE AFTER ADJUSTMENT 0.38
THERMAL MASS
6> EXTERIOR AIR FILM R-VALUE 0.38
7> INTERIOR AIR FILM R-VALUE: HORIZONTAL 0.77
8> INTERIOR AIR FILM R-VALUE: VERTICAL 0.68
9> CRITICAL THICKNESS CONSTANT 10.5
VENTILATION
10> VENT AZIMUTH DEPENDENCY (Independ, Depend) ..... Independent
11> VENT DIRECTION INDEPENDENT WIND FACTOR 0.275
SIMULATION CONTROL
12> NUMBER OF WARMUP DAYS (10 maximum) 3
13> STARTING DAY OF YEAR (Sun, Mon, etc) ..... Sun
SEASON MODE
14> SWITCH-OVER TEMP (deg F) 60
15> NUMBER OF DAYS TO AVERAGE TEMP (1 or more) 7

MICROPAS4 v4.01 File-SAC1BC3J Wth-CTZ12S92 Program-TABLE
Run-1 story post-83 base case Project-SMUD shade tree impact Date-04/24/95

Space Conditioning Source Energy Use (kBtu/sqft)	
Conditioned Floor Area (sqft).....	1700
Heating Fuel Use.....	15.87
Heating Electric Use.....	0.63
Cooling Electric Use.....	6.85
Total Heating Use.....	16.50
Total Cooling Use.....	6.85
Total Fuel Use.....	15.87
Total Electric Use.....	7.49
Total Energy Use.....	23.36

Peak Conditions

	UNITS	MINIMUM VALUE	MINIMUM PERIOD	MINIMUM DAY	MINIMUM HOUR	MAXIMUM VALUE	MAXIMUM PERIOD	MAXIMUM DAY	MAXIMUM HOUR
BUILDING									
HEATLOAD	(kBtu)	0	January	1	1	82011	January	3	8
COOLLOAD	(kBtu)	-30852	August	7	16	0	January	1	1
HEATFUEL	(kBtu)	0	January	1	1	103348	January	3	8
HEATELEC	(kWh)	0.0	January	1	1	402.7	January	3	8
COOLELEC	(kWh)	0.0	January	1	1	3085.2	August	7	16
OFFPEAK	(kWh)	0	January	1	1	2901	August	6	15
MIDPEAK	(kWh)	0	January	1	1	0	January	1	1
ONPEAK	(kWh)	0	January	1	1	3085	August	7	16
TOTAL	(kWh)	0	January	1	1	3085	August	7	16
PEAKUSE	(kWh)	0	January	1	1	3085	August	7	16
AMBIENT									
NORMAL	(Btu/sf)	0	January	1	1	335	March	31	11
HORZDIF	(Btu/sf)	0	January	1	1	142	April	23	12
HORZDIR	(Btu/sf)	0	January	1	1	305	May	4	13
HORZTOT	(Btu/sf)	0	January	1	1	328	June	5	13
DRYBULB	(F)	27.0	December	24	7	103.0	July	24	16
WINDVEL	(mph)	0	January	5	1	14	February	15	14
HOUSE									
HOUSE	(F)	60.0	January	1	6	78.0	March	20	16
HEATLOAD	(kBtu)	0	January	1	1	82011	January	3	8
HEATFUEL	(kBtu)	0	January	1	1	103348	January	3	8
HEATELEC	(kWh)	0.0	January	1	1	402.7	January	3	8
HEATING	(hours)	0	January	1	1	1	January	1	6
COOLLOAD	(kBtu)	-30852	August	7	16	0	January	1	1
COOLELEC	(kWh)	0.0	January	1	1	3085.2	August	7	16
COOLING	(hours)	0	January	1	1	1	March	20	16
COOLOUT	(hours)	0	January	1	1	1	March	20	16

Peak Conditions

	UNITS	MINIMUM VALUE	MINIMUM PERIOD	MINIMUM DAY	MINIMUM HOUR	MAXIMUM VALUE	MAXIMUM PERIOD	MAXIMUM DAY	MAXIMUM HOUR
COOLNOT	(hours)	0	January	1	1	0	January	1	1
DUCTLOAD	(kBtu)	-13942	January	3	8	5862	August	7	16
VENTLOAD	(kBtu)	-22451	April	17	16	0	January	1	1
VENTACH	(ach)	0.00	January	1	1	11.02	May	20	14
VENTING	(hours)	0	January	1	1	1	February	27	17
ESLAB									
ESLAB	(F)	62.6	January	3	7	77.6	July	28	23
CSLAB									
CSLAB	(F)	64.8	January	5	7	76.6	August	7	21

Period Time Of Use for Run

Period	OFFPEAK (kWh)	MIDPEAK (kWh)	ONPEAK (kWh)	TOTAL (kWh)	PEAKUSE (kWh)
January	28	0	3	31	0
February	16	0	2	17	0
March	10	0	1	11	1
April	20	0	10	30	1
May	29	0	59	88	2
June	71	0	135	206	3
July	117	0	205	322	3
August	110	0	177	287	3
September	62	0	100	162	2
October	9	0	35	45	2
November	13	0	1	14	1
December	27	0	3	30	0
	511	0	732	1243	3

MICROPAS4 v4.01 File-SAC1BC3J Wth-CTZ12S92 Program-TABLE
Run-1 story post-83 base case Project-SMUD shade tree impact Date-04/24/95

Period HOUSE Hours Of Use for Run

Period	HEATING (hours)	COOLING (hours)	COOLOUT (hours)	COOLNOT (hours)	VENTING (hours)
January	454	0	0	0	0
February	262	0	0	0	4
March	124	2	2	0	14
April	47	34	10	0	40
May	0	87	6	0	291
June	0	161	12	0	327
July	0	226	7	0	343
August	0	199	5	0	333
September	0	141	6	0	334
October	5	52	3	0	270
November	179	3	3	0	8
December	439	0	0	0	0
	1510	905	54	0	1964

Period HOUSE Energy for Run

Period	HEATFUEL (kBtu)	HEATELEC (kWh)	COOLELEC (kWh)
January	7872	31	0
February	4464	17	0
March	2516	10	1
April	1043	4	26
May	0	0	88
June	0	0	206
July	0	0	322
August	0	0	287
September	0	0	162
October	207	1	44
November	3109	12	2
December	7769	30	0
	26980	105	1138

Hourly HOUSE Loads for August Day 7

Hour	HOUSE (F)	HEATLOAD (Btu)	COOLLOAD (Btu)	DUCTLOAD (Btu)	VENTLOAD (Btu)	VENTACH (ach)
1	75.9	0	0	0	-3078	3.01
2	75.4	0	0	0	-3080	2.72
3	74.9	0	0	0	-2723	2.68
4	74.3	0	0	0	-3819	2.80
5	73.6	0	0	0	-3723	2.55
6	73.2	0	0	0	-3393	2.50
7	73.8	0	0	0	-1832	2.56
8	74.5	0	0	0	-3629	4.01
9	75.9	0	0	0	-731	3.10
10	78.0	0	-886	168	0	0.00
11	78.0	0	-18607	3535	0	0.00
12	78.0	0	-19825	3767	0	0.00
13	78.0	0	-23583	4481	0	0.00
14	78.0	0	-25848	4911	0	0.00
15	78.0	0	-29948	5690	0	0.00
16	78.0	0	-30852	5862	0	0.00
17	78.0	0	-27578	5240	0	0.00
18	78.0	0	-20178	3834	0	0.00
19	78.0	0	-11339	2154	0	0.00
20	78.0	0	-2220	422	0	0.00
21	77.6	0	0	0	-2212	3.24
22	76.8	0	0	0	-4296	2.85
23	76.0	0	0	0	-4009	2.22
24	74.8	0	0	0	-5611	2.76
	76.4	0	-210863	40064	-42134	1.54

MICROPAS4 v4.01 File-SAC1BC3J Wth-CTZ12S92 Program-TABLE
Run-1 story post-83 base case Project-SMUD shade tree impact Date-04/24/95

Hourly HOUSE Heatflows for August Day 7

Hour	INFILBTU (Btu)	INFILACH (ach)	INTGAIN (Btu)	OPAQCOND (Btu)	OPAQSOLR (Btu)	GLAZCOND (Btu)	GLAZSOLR (Btu)	ESLAB (Btu)
1	-287	0.29	961	-1170	0	-578	0	460
2	-285	0.26	881	-1294	0	-639	0	600
3	-253	0.25	841	-1162	0	-574	0	671
4	-353	0.26	841	-1557	0	-769	0	826
5	-340	0.24	841	-1671	0	-825	0	924
6	-311	0.23	1041	-1548	66	-765	230	943
7	-171	0.24	1522	-817	683	-404	2643	595
8	-342	0.38	2362	-1034	1469	-511	5212	274
9	-69	0.30	2242	-270	1824	-133	6048	-293
10	395	0.39	2402	1185	2740	586	8013	-988
11	1183	0.42	2362	3260	3363	1611	5166	-770
12	1470	0.36	1842	4742	3451	2343	3999	-713
13	2501	0.47	1802	6223	3353	3075	3761	-593
14	2789	0.48	1201	6816	3558	3368	4722	-533
15	3838	0.60	1121	7409	3549	3660	6068	-450
16	4656	0.73	1241	7409	3072	3660	6255	-401
17	3145	0.56	2282	6520	2422	3221	5950	-340
18	2014	0.56	2563	4149	1660	2050	5039	-302
19	838	0.47	2563	2074	751	1025	2982	-257
20	95	0.37	2082	296	28	146	139	-228
21	-208	0.31	2002	-780	0	-386	0	-51
22	-396	0.27	2202	-1720	0	-850	0	252
23	-357	0.20	1762	-2069	0	-1022	0	503
24	-509	0.25	1081	-2321	0	-1147	0	850
	19044	0.37	40040	32670	31990	16140	66227	977

Hourly HOUSE Heatflows for August Day 7

Hour	CSLAB (Btu)
1	79
2	359
3	559
4	866
5	1128
6	1281
7	952
8	558
9	-173
10	-1190
11	-1105
12	-1076
13	-1021
14	-985
15	-939
16	-903
17	-863
18	-829
19	-792
20	-761
21	-543
22	-112
23	295
24	849
	-4365

SACRAMENTO SHADE TREE PROGRAM SENSITIVITY ANALYSIS
LARGE ADJACENT TREE SCENARIO

Energy-Efficient Building
1 Story Wood Frame (1,700 sq ft)
Wall = R-11, Ceiling/Roof = R-30
Cooling: 1,138 kWh/yr, Peak: 1.8 kW
Climate Zone: Sacramento
Tree Size: **Large** Distance: **Adjacent** Direction: **West**

Sheet Name: LA
Cost / tree: $39.00
Trees Planted: 100
Discount Rate: 5.90%

Adjustments:
Tree Mortality per Year

Years 1 - 2:	10.00%
Year 3-5:	5.00%
Year 6-10:	1.00%
Year 11-20:	0.50%
Years 21-30:	1.50%
AC Present:	100.00%

Yr	Growth Curve	Unadj. kWh/tree	Unadj. kW/tree	Mortality # Live Trees	Adjusted Mortality Total kWh	Adjusted Mortality Total kW	Adjusted AC Sat Total kWh	Adjusted AC Sat Total kW	Adjusted Savings Per Planted Tree kWh/tree	kw/tree	Yr	Nominal Avoided Co kWh $	kW $	Adjusted Nominal Savings (A kWh Save Total $	kW Saved Total $	kWh+kW Total $
1994/0	0.00	0	0	0	0	0	0	0	0	0	1994/0	$0.0000	$0.00	$0	$0	$0
1995/1	0.01	3	0.00	90	253	0	253	0	3	0.00	1995/1	$0.0311	$15.27	$8	$3	$11
1996/2	0.02	6	0.00	81	509	0	509	0	5	0.00	1996/2	$0.0306	$16.36	$16	$6	$22
1997/3	0.04	11	0.01	77	855	1	855	1	9	0.01	1997/3	$0.0277	$17.40	$24	$12	$35
1998/4	0.07	17	0.01	73	1,259	1	1,259	1	13	0.01	1998/4	$0.0283	$19.39	$36	$19	$55
1999/5	0.10	25	0.02	69	1,704	1	1,704	1	17	0.01	1999/5	$0.0300	$20.18	$51	$27	$78
2000/6	0.13	33	0.03	69	2,269	2	2,269	2	23	0.02	2000/6	$0.0334	$102.19	$76	$180	$256
2001/7	0.17	43	0.03	68	2,894	2	2,894	2	29	0.02	2001/7	$0.0338	$106.21	$98	$239	$337
2002/8	0.21	53	0.04	67	3,569	3	3,569	3	36	0.03	2002/8	$0.0376	$110.40	$134	$307	$441
2003/9	0.25	64	0.05	67	4,286	3	4,286	3	43	0.03	2003/9	$0.0391	$114.74	$168	$383	$550
2004/10	0.30	76	0.06	66	5,035	4	5,035	4	50	0.04	2004/10	$0.0431	$122.21	$217	$479	$696
2005/11	0.35	89	0.07	66	5,835	5	5,835	5	58	0.05	2005/11	$0.0495	$131.47	$289	$597	$886
2006/12	0.40	102	0.08	65	6,655	5	6,655	5	67	0.05	2006/12	$0.0536	$136.57	$357	$707	$1,064
2007/13	0.45	115	0.09	65	7,486	6	7,486	6	75	0.06	2007/13	$0.0547	$141.87	$409	$827	$1,236
2008/14	0.50	128	0.10	65	8,318	6	8,318	6	83	0.06	2008/14	$0.0585	$147.38	$487	$954	$1,441
2009/15	0.55	142	0.11	64	9,142	7	9,142	7	91	0.07	2009/15	$0.0609	$153.10	$557	$1,089	$1,646
2010/16	0.60	155	0.12	64	9,947	8	9,947	8	99	0.08	2010/16	$0.0649	$159.05	$646	$1,231	$1,877
2011/17	0.65	168	0.13	64	10,726	8	10,726	8	107	0.08	2011/17	$0.0670	$165.23	$719	$1,379	$2,098
2012/18	0.70	181	0.14	63	11,469	9	11,469	9	115	0.09	2012/18	$0.0700	$171.64	$803	$1,532	$2,335
2013/19	0.75	193	0.15	63	12,168	9	12,168	9	122	0.09	2013/19	$0.0748	$178.31	$910	$1,689	$2,599
2014/20	0.79	204	0.16	63	12,816	10	12,816	10	128	0.10	2014/20	$0.0790	$185.20	$1,012	$1,847	$2,860
2015/21	0.83	214	0.17	62	13,271	10	13,271	10	133	0.10	2015/21	$0.0817	$190.08	$1,084	$1,963	$3,047
2016/22	0.87	224	0.17	61	13,651	11	13,651	11	137	0.11	2016/22	$0.0857	$195.85	$1,170	$2,081	$3,251
2017/23	0.90	232	0.18	60	13,955	11	13,955	11	140	0.11	2017/23	$0.0885	$201.52	$1,235	$2,188	$3,423
2018/24	0.93	240	0.19	59	14,178	11	14,178	11	142	0.11	2018/24	$0.0919	$207.07	$1,303	$2,285	$3,588
2019/25	0.96	246	0.19	58	14,321	11	14,321	11	143	0.11	2019/25	$0.0952	$212.50	$1,363	$2,368	$3,732
2020/26	0.98	251	0.20	57	14,383	11	14,383	11	144	0.11	2020/26	$0.0986	$217.81	$1,418	$2,438	$3,856
2021/27	0.99	254	0.20	57	14,364	11	14,364	11	144	0.11	2021/27	$0.1049	$222.99	$1,507	$2,493	$3,999
2022/28	1.00	256	0.20	56	14,266	11	14,266	11	143	0.11	2022/28	$0.1051	$228.04	$1,499	$2,532	$4,031
2023/29	1.00	257	0.20	55	14,090	11	14,090	11	141	0.11	2023/29	$0.1084	$232.95	$1,527	$2,554	$4,082
2024/30	1.00	257	0.20	54	13,879	11	13,879	11	139	0.11	2024/30	$0.1116	$237.73	$1,549	$2,568	$4,117
			30-yr Loss:	46%		Totals:	257,555	200	2,576	2.00				$20,670	$36,976	$57,647

SUMMARY OF ECONOMIC ANALYSIS

	PV of Benefits	PV of Costs
Fixed:	na	$3,900
Variable:	na	na
Capacity:	$11,797	na
Energy:	$6,469	na
TOTAL:	$18,266	$3,900

Net Present Value: $14,366
(Benefits -Costs)

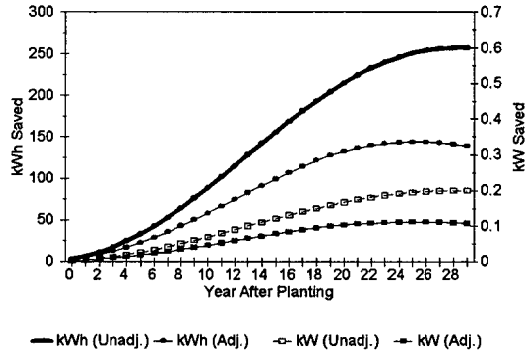
Benefit to Cost Ratl **4.68**
(Benefits / Costs)

Estimated Savings (All Trees):
Average Peak Cap 7 kW-yr
Average Energy: 8,585 kWh / yr

Estimated Savings (Per Tree Planted):
Average Peak Cap 0.07 kW-yr
Average Energy: 85.85 kWh / yr

Assumptions:
1) 30 year analysis from 1995 - 2024
2) 100 trees planted in 1995, 1 per residence, at $39/tree, which includes costs of the tree, stakes and other planting materials, program adminstration, overhead and 3 year follow-up for tree care and public education (assumes residents plant trees).
3) Assume "typical" tree is 5-ft tall when planted (5-gal).
4) Assume unadjusted annual savings as shown based on US Forest Service energy simulations w/ Micropas and SPS.
5) Assume annual energy savings pattern is linked to tree growth and follows an "S" shaped growth curve.
6) Assume adjustment to both energy and capacity savings based on tree mortality as shown.
7) Assume no adjustment to both energy and capacity savings for air conditioning saturation since base case home has cooling device.
8) Assume nominal discount rate of 5.9%, and avoided energy and capacity costs as shown.

Energy and Capacity Savings Per Tree



Consumption w/ 1 tree					Avg. Annual Savings Per Tree		
Base	Shade	ET+Wind	Total	Title 24	Shade	ET+Wind	Total
1,138	881	0	881	kWh	257	0	257
				% kWh	22.6%	0.0%	22.58%
1.80	1.60	0.00	1.60	kW	0.20	0.00	0.20
				% kW	11.1%	0.0%	11.11%

APPENDIX D

Table D-1. Existing Trees of Different Sizes for the Sample, Projected for All Residential Units, and Adjusted to the Medium-Sized Reference Tree.

		Numbers for Sample			Projected for All Units			Adjusted and Projected		
SubRAD	n	Small	Medium	Large	Small	Medium	Large	MAT	SD	PAT
12	12	0	3	0	0	245	0	1.50	0.71	245
21	32	96	37	13	7,644	2,946	1,035	4.63	4.54	11,785
22	29	37	60	14	1,545	2,506	585	4.47	4.04	5,418
23	51	60	70	18	2,884	3,364	865	3.31	3.38	8,122
31	87	96	114	21	10,802	12,827	2,363	2.86	2.16	28,017
32	62	33	67	26	6,505	13,207	5,125	2.74	2.19	33,460
33	4	12	3	0	417	104	0	3.00	2.74	417
41	94	60	54	4	6,516	5,864	434	1.18	1.40	12,054
42	120	86	93	19	2,387	2,581	527	1.79	1.97	5,952
43	104	68	104	24	7,286	11,144	2,572	2.18	1.94	24,324
44	113	50	118	40	3,292	7,769	2,634	2.44	2.19	18,139
51	69	57	113	51	3,501	6,940	3,132	4.47	3.88	18,964
52	133	154	160	44	5,873	6,102	1,678	3.06	2.38	15,540
61	48	52	83	24	3,274	5,226	1,511	4.04	4.18	12,214
62	16	5	9	0	898	1,617	0	0.80	1.57	2,291
63	25	11	12	8	2,069	2,257	1,505	1.77	2.11	8,323
71	3	9	3	2	981	327	218	5.25	4.63	1,717
73	41	77	23	4	16,085	4,805	836	2.26	1.99	19,376
74	1	1	0	0	286	0	0	0.75	0.00	215
81	31	62	60	10	9,014	8,723	1,454	4.40	4.09	19,845
82	57	105	112	22	18,998	20,264	3,980	4.50	4.20	46,454
83	22	36	68	17	2,695	5,091	1,273	6.64	4.22	10,930
84	11	9	19	2	976	2,061	217	2.89	2.34	3,443
91	43	63	75	16	5,584	6,647	1,418	3.96	2.39	15,089
92	88	122	123	43	9,825	9,906	3,463	3.90	2.65	27,663
93	121	191	304	48	12,925	20,572	3,248	4.89	2.94	40,010
94	52	118	90	29	20,861	15,911	5,127	5.11	4.20	46,937

SubRAD	n	Numbers for Sample			Projected for All Units			Adjusted and Projected		
		Small	Medium	Large	Small	Medium	Large	MAT	SD	PAT
100	69	55	108	32	12,452	24,452	7,245	3.55	3.11	55,526
111	53	52	66	27	2,440	3,097	1,267	3.51	2.56	8,728
112	69	66	121	20	7,334	13,445	2,222	3.34	2.19	25,612
121	75	25	69	28	3,353	9,255	3,756	2.29	2.07	23,037
122	78	27	91	61	3,316	11,176	7,491	3.77	2.98	36,136
123	24	14	16	1	4,021	4,595	287	1.23	1.39	8,473
124	9	3	5	2	715	1,192	477	1.47	2.04	3,159
131	4	0	8	2	0	638	160	3.50	1.73	1,117
133	13	13	15	7	715	825	385	3.52	1.61	2,516
134	39	27	49	12	1,791	3,250	796	2.70	1.80	6,982
135	34	54	50	13	3,618	3,350	871	3.81	2.35	8,677
136	2	5	3	1	1,000	600	200	4.88	2.30	1,950
137	29	51	20	22	2,358	925	1,017	4.28	3.86	5,745
141	56	101	81	38	23,717	19,021	8,923	4.83	3.87	63,578
142	78	136	77	14	5,466	3,095	563	2.83	1.80	8,883
143	63	85	121	14	8,036	11,439	1,324	3.60	2.67	21,437
144	75	179	47	5	20,463	5,373	572	2.62	2.46	22,435
145	33	57	32	3	10,224	5,740	538	2.54	1.92	15,022
151	66	60	89	39	8,589	12,740	5,583	3.80	3.10	35,931
152	19	24	32	7	4,050	5,400	1,181	3.74	2.89	11,980
153	83	83	115	27	15,168	21,016	4,934	3.11	2.44	47,194
161	58	83	71	11	13,708	11,726	1,817	2.87	2.15	27,457
162	31	39	29	6	7,769	5,777	1,195	2.46	2.78	15,189
163	72	41	19	3	8,215	3,807	601	0.82	1.56	11,771
164	70	119	29	4	22,906	5,582	770	1.86	2.03	25,071
170	10	9	7	1	2,628	2,044	292	1.68	1.99	4,891
181	42	37	12	2	7,029	2,280	380	1.09	1.50	8,691
191	26	22	8	3	812	295	111	1.29	1.67	1,237
192	9	2	9	1	242	1,091	121	1.50	2.32	1,637
193	51	25	46	8	2,949	5,425	944	1.74	1.49	10,467

SubRAD	n	Numbers for Sample			Projected for All Units			Adjusted and Projected		
		Small	Medium	Large	Small	Medium	Large	MAT	SD	PAT
211	32	48	49	7	5,703	5,822	832	3.31	2.98	12,594
212	19	15	15	2	883	883	118	1.70	3.68	1,898
240	8	8	11	6	1,325	1,822	994	4.38	3.18	5,797
250	63	22	25	5	2,888	3,282	656	0.90	1.86	7,417
Totals	2,931	3,257	3,522	933	379,004	389,462	103,821	3.00[a]	0.08[b]	985,177

[a] Overall mean.
[b] Standard error of the overall mean.

Table D-2. Number of Existing Trees At Different Locations Around the Sample and Projected for All Residential Units.

Sub-	Numbers for the Sample								Projected for All Residential Units							
RAD	N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW
12	1	1	0	0	0	0	0	1	82	82	0	0	0	0	0	82
21	14	14	22	20	31	16	14	15	1,115	1,115	1,752	1,593	2,468	1,274	1,115	1,194
22	11	11	13	16	18	13	14	15	459	459	543	668	752	543	585	626
23	26	17	17	20	27	11	18	12	1,250	817	817	961	1,298	529	865	577
31	34	17	58	9	48	7	47	11	3,826	1,913	6,526	1,013	5,401	788	5,288	1,238
32	32	0	17	6	32	12	24	3	6,308	0	3,351	1,183	6,308	2,365	4,731	591
33	2	1	3	2	3	2	0	2	70	35	104	70	104	70	0	70
41	22	4	22	15	25	7	10	13	2,389	434	2,389	1,629	2,715	760	1,086	1,412
42	36	18	27	11	37	18	34	17	999	500	749	305	1,027	500	944	472
43	37	14	30	14	36	15	34	16	3,965	1,500	3,215	1,500	3,858	1,607	3,643	1,714
44	31	14	35	20	45	18	30	15	2,041	922	2,304	1,317	2,963	1,185	1,975	988
51	32	15	30	20	34	28	42	20	1,965	921	1,843	1,228	2,088	1,720	2,580	1,228
52	74	29	35	38	63	41	43	35	2,822	1,106	1,335	1,449	2,403	1,564	1,640	1,335
61	23	16	11	22	20	21	26	20	1,448	1,007	693	1,385	1,259	1,322	1,637	1,259
62	1	2	2	2	2	1	0	4	180	359	359	359	359	180	0	719
63	3	8	2	2	5	7	2	2	564	1,505	376	376	940	1,317	376	376
71	1	3	4	0	3	2	1	0	109	327	436	0	327	218	109	0
73	12	8	21	8	18	12	17	8	2,507	1,671	4,387	1,671	3,760	2,507	3,551	1,671
74	1	0	0	0	0	0	0	0	286	0	0	0	0	0	0	0
81	23	7	19	7	24	15	18	19	3,344	1,018	2,762	1,018	3,489	2,181	2,617	2,762
82	38	22	35	31	38	14	40	21	6,875	3,980	6,333	5,609	6,875	2,533	7,237	3,800
83	26	11	18	9	21	6	23	7	1,946	824	1,348	674	1,572	449	1,722	524
84	5	5	2	2	6	3	6	1	542	542	217	217	651	325	651	108
91	21	9	29	12	25	11	33	14	1,861	798	2,570	1,064	2,216	975	2,925	1,241
92	68	15	47	15	54	20	49	20	5,476	1,208	3,785	1,208	4,349	1,611	3,946	1,611
93	90	53	64	58	77	81	63	57	6,090	3,586	4,331	3,925	5,211	5,481	4,263	3,857
94	52	17	29	23	46	17	36	17	9,193	3,005	5,127	4,066	8,132	3,005	6,364	3,005
100	27	15	27	17	40	14	32	23	6,113	3,396	6,113	3,849	9,056	3,170	7,245	5,207
111	25	10	21	3	32	11	32	11	1,173	469	985	141	1,502	516	1,502	516
112	47	21	30	13	38	12	32	14	5,222	2,333	3,333	1,445	4,222	1,333	3,556	1,556
121	27	11	10	11	23	7	20	13	3,622	1,475	1,341	1,475	3,085	939	2,683	1,744
122	22	16	20	34	21	14	22	30	2,702	1,965	2,456	4,175	2,579	1,719	2,702	3,684
123	3	3	0	3	4	1	4	4	1,292	1,292	0	1,292	1,723	431	1,723	1,723
124	1	0	1	0	4	0	0	0	429	0	429	0	1,717	0	0	0

Sub-	Numbers for the Sample								Projected for All Residential Units							
RAD	N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW
131	0	1	0	0	1	0	0	1	0	319	0	0	319	0	0	319
133	9	1	6	0	10	1	7	1	495	55	330	0	550	55	385	55
134	14	2	19	9	25	4	10	5	929	133	1,260	597	1,658	265	663	332
135	23	14	18	9	18	9	12	14	1,541	938	1,206	603	1,206	603	804	938
136	6	0	2	0	1	0	0	0	1,200	0	400	0	200	0	0	0
137	13	4	15	4	16	9	23	9	601	185	694	185	740	416	1,064	416
141	35	26	19	30	27	29	22	32	8,219	6,105	4,462	7,045	6,340	6,810	5,166	7,514
142	45	19	37	8	57	7	46	8	1,809	764	1,487	322	2,291	281	1,849	322
143	25	22	28	22	31	33	31	28	2,363	2,080	2,647	2,080	2,931	3,120	2,931	2,647
144	26	32	26	16	30	38	28	35	2,972	3,658	2,972	1,829	3,430	4,344	3,201	4,001
145	13	6	12	5	13	6	22	15	2,332	1,076	2,152	897	2,332	1,076	3,946	2,690
151	21	18	28	27	10	33	27	24	3,006	2,577	4,008	3,865	1,432	4,724	3,865	3,436
152	13	3	10	5	13	6	9	4	2,194	506	1,687	844	2,194	1,012	1,519	675
153	31	14	46	15	30	16	61	12	5,665	2,558	8,406	2,741	5,482	2,924	11,148	2,193
161	26	7	35	9	28	11	39	10	4,294	1,156	5,780	1,486	4,624	1,817	6,441	1,652
162	12	10	13	6	9	4	15	5	2,390	1,992	2,590	1,195	1,793	797	2,988	996
163	11	5	7	6	9	6	17	2	2,204	1,002	1,403	1,202	1,803	1,202	3,406	401
164	18	15	18	25	29	16	16	15	3,465	2,887	3,465	4,812	5,582	3,080	3,080	2,887
170	1	0	0	0	0	0	1	0	1,460	0	0	0	0	0	1,460	0
181	6	5	4	5	9	1	9	12	1,140	950	760	950	1,710	190	1,710	2,280
191	6	1	9	0	10	1	5	1	222	37	332	0	369	37	185	37
192	3	2	1	0	2	1	2	1	364	242	121	0	242	121	121	242
193	15	4	10	3	17	1	23	6	1,769	472	1,179	354	2,005	118	2,713	708
211	21	4	13	11	20	12	10	13	2,495	475	1,545	1,307	2,376	1,426	1,188	1,545
212	3	2	3	4	7	8	4	1	177	118	177	235	412	471	235	59
240	3	1	1	1	3	2	11	3	497	166	166	166	497	331	1,822	497
250	5	5	10	6	10	4	9	3	656	656	1,313	788	1,313	525	1,181	394
Total	1,272	630	1,091	689	1,335	715	1,225	720	142,723	71,673	122,851	80,367	148,239	78,861	142,329	84,125

Table D-3. Mean Number of Existing Trees At Different Directions Per Residential Unit When Adjusted to the Medium-Sized Reference Tree and Standard Deviations.

Sub-	n	N		NE		E		SE		S		SW		W		NW	
RAD		MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD
12	12	0.50	0.71	0.50	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.71
21	32	0.56	1.07	0.43	0.84	0.70	1.19	0.49	1.12	1.03	1.38	0.55	0.87	0.34	0.58	0.52	0.91
22	29	0.39	0.67	0.34	0.59	0.59	0.97	0.65	1.01	0.88	1.47	0.49	0.95	0.59	1.05	0.55	0.89
23	51	0.60	1.11	0.42	0.90	0.34	0.67	0.38	0.76	0.56	0.99	0.19	0.40	0.43	0.89	0.39	0.90
31	87	0.37	0.60	0.20	0.52	0.70	1.03	0.09	0.28	0.62	0.87	0.07	0.32	0.69	1.06	0.13	0.43
32	62	0.78	1.35	0.00	0.00	0.35	0.77	0.12	0.47	0.69	1.17	0.24	0.64	0.48	0.85	0.08	0.42
33	4	0.50	1.00	0.19	0.38	0.56	0.72	0.38	0.43	0.63	0.75	0.38	0.75	0.00	0.00	0.38	0.43
41	94	0.24	0.60	0.04	0.18	0.21	0.53	0.14	0.40	0.26	0.60	0.06	0.27	0.12	0.42	0.12	0.37
42	120	0.39	0.78	0.13	0.35	0.23	0.53	0.08	0.28	0.33	0.67	0.15	0.44	0.34	0.74	0.14	0.41
43	104	0.39	0.81	0.13	0.50	0.39	0.92	0.13	0.36	0.39	0.84	0.17	0.51	0.38	0.79	0.20	0.60
44	113	0.39	0.84	0.15	0.55	0.36	0.79	0.19	0.55	0.61	1.14	0.22	0.68	0.36	0.89	0.16	0.54
51	69	0.59	1.06	0.32	0.82	0.52	0.86	0.33	0.62	0.72	1.26	0.62	1.20	0.99	1.63	0.39	0.82
52	133	0.61	0.96	0.19	0.45	0.33	0.82	0.32	0.71	0.58	1.05	0.32	0.74	0.42	0.93	0.30	0.82
61	48	0.58	1.19	0.44	1.00	0.30	0.80	0.57	0.94	0.45	1.11	0.61	1.63	0.58	1.12	0.51	0.82
62	16	0.06	0.25	0.11	0.30	0.11	0.30	0.13	0.34	0.11	0.30	0.05	0.19	0.00	0.00	0.23	0.72
63	25	0.18	0.62	0.44	1.01	0.16	0.62	0.07	0.24	0.44	1.33	0.35	0.74	0.07	0.35	0.06	0.30
71	3	0.25	0.43	1.00	1.00	1.75	1.56	0.00	0.00	1.50	1.50	0.50	0.43	0.25	0.43	0.00	0.00
73	41	0.28	0.63	0.22	0.55	0.41	0.63	0.16	0.38	0.34	0.76	0.29	0.62	0.40	0.68	0.16	0.53
74	1	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
81	31	0.77	0.99	0.17	0.46	0.66	1.27	0.29	0.64	0.67	0.91	0.40	0.93	0.68	1.04	0.76	1.36
82	57	0.78	1.29	0.42	0.88	0.66	1.03	0.56	1.10	0.69	0.95	0.26	0.75	0.71	1.31	0.42	0.89
83	22	1.95	3.18	0.47	0.90	0.81	1.09	0.45	0.84	1.00	1.22	0.27	0.46	1.40	2.52	0.28	0.69
84	11	0.39	0.45	0.45	0.52	0.18	0.40	0.16	0.36	0.52	0.68	0.25	0.58	0.86	1.81	0.07	0.23
91	43	0.48	0.72	0.35	1.19	0.89	1.52	0.30	0.65	0.55	0.87	0.27	0.63	0.69	1.09	0.42	0.83
92	88	0.97	1.32	0.22	0.66	0.65	1.15	0.17	0.54	0.65	0.99	0.26	0.63	0.61	0.96	0.37	1.15
93	121	0.84	1.18	0.48	0.91	0.50	0.83	0.54	1.05	0.66	0.93	0.74	1.37	0.64	1.04	0.48	0.96
94	52	0.99	1.48	0.45	1.21	0.61	0.97	0.56	1.19	0.88	1.19	0.29	0.53	0.88	1.37	0.44	0.89
100	69	0.47	0.85	0.27	0.74	0.47	0.82	0.35	0.79	0.60	0.87	0.28	0.90	0.68	1.08	0.43	1.01
111	53	0.57	1.00	0.24	0.66	0.46	0.94	0.13	0.59	0.85	1.19	0.24	0.57	0.75	1.00	0.27	0.65
112	69	0.74	0.97	0.32	0.61	0.51	1.07	0.16	0.43	0.55	0.75	0.25	0.69	0.60	1.05	0.21	0.53
121	75	0.53	1.02	0.22	0.86	0.20	0.69	0.18	0.55	0.45	0.97	0.11	0.42	0.37	0.83	0.22	0.65
122	78	0.43	1.01	0.29	0.74	0.46	1.09	0.75	1.20	0.33	0.79	0.25	0.64	0.56	1.23	0.71	1.36
123	24	0.23	0.48	0.10	0.38	0.00	0.00	0.20	0.47	0.20	0.57	0.07	0.25	0.16	0.36	0.27	0.80

Sub-RAD	n	N		NE		E		SE		S		SW		W		NW	
		MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD
124	9	0.31	0.63	0.00	0.00	0.33	1.00	0.00	0.00	0.75	1.09	0.00	0.00	0.00	0.00	0.08	0.25
131	4	0.75	1.50	1.25	0.96	0.00	0.00	0.25	0.50	0.25	0.50	0.00	0.00	0.00	0.00	1.00	1.41
133	13	0.96	1.33	0.08	0.28	0.71	1.74	0.00	0.00	0.63	0.85	0.08	0.28	0.98	1.75	0.08	0.28
134	39	0.53	0.93	0.04	0.28	0.61	0.98	0.27	0.63	0.81	0.97	0.10	0.38	0.21	0.56	0.12	0.31
135	34	0.67	1.13	0.32	0.68	0.52	0.86	0.29	0.64	0.67	1.09	0.43	0.94	0.43	0.80	0.47	0.90
136	2	3.50	2.83	0.00	0.00	0.88	0.18	0.00	0.00	0.50	0.71	0.00	0.00	0.00	0.00	0.00	0.00
137	29	0.69	1.40	0.19	0.60	0.70	1.39	0.18	0.59	0.59	0.87	0.57	1.47	0.89	1.28	0.47	1.21
141	56	0.66	1.04	0.50	1.05	0.38	0.84	0.85	1.62	0.64	1.20	0.60	1.18	0.56	1.46	0.65	1.36
142	78	0.60	0.89	0.20	0.43	0.45	0.91	0.08	0.29	0.75	0.96	0.07	0.24	0.57	0.98	0.12	0.46
143	63	0.42	0.87	0.37	0.75	0.40	0.70	0.41	1.07	0.53	0.94	0.48	0.82	0.51	0.90	0.47	0.86
144	75	0.28	0.60	0.34	0.62	0.33	0.83	0.17	0.42	0.33	0.51	0.40	0.77	0.35	0.77	0.41	0.76
145	33	0.39	0.64	0.15	0.33	0.31	0.46	0.13	0.37	0.36	0.58	0.14	0.36	0.54	0.81	0.52	0.90
151	66	0.53	1.85	0.23	0.54	0.46	0.86	0.59	1.04	0.27	0.93	0.66	1.35	0.57	1.08	0.49	1.23
152	19	1.18	2.22	0.16	0.37	0.46	0.78	0.36	0.82	0.74	0.92	0.26	0.73	0.42	0.67	0.16	0.40
153	83	0.39	0.80	0.20	0.71	0.68	1.03	0.20	0.61	0.46	1.04	0.17	0.47	0.88	1.27	0.13	0.37
161	58	0.42	0.85	0.14	0.47	0.72	1.39	0.13	0.32	0.46	0.76	0.16	0.42	0.69	0.94	0.14	0.37
162	31	0.33	0.60	0.26	0.52	0.58	1.12	0.16	0.43	0.33	0.99	0.10	0.26	0.49	1.04	0.21	0.65
163	72	0.16	0.46	0.06	0.26	0.08	0.25	0.07	0.30	0.11	0.33	0.06	0.24	0.25	0.92	0.02	0.12
164	70	0.24	0.60	0.20	0.53	0.21	0.64	0.31	0.68	0.36	0.74	0.18	0.51	0.19	0.47	0.17	0.45
170	10	0.60	1.26	0.00	0.00	0.15	0.47	0.00	0.00	0.40	0.97	0.20	0.42	0.25	0.54	0.08	0.24
181	42	0.17	0.67	0.10	0.33	0.07	0.22	0.16	0.53	0.18	0.39	0.02	0.12	0.16	0.45	0.24	0.77
191	26	0.18	0.40	0.03	0.15	0.26	0.63	0.00	0.00	0.43	0.81	0.12	0.59	0.23	0.66	0.04	0.20
192	9	0.53	1.25	0.22	0.44	0.11	0.33	0.00	0.00	0.22	0.44	0.11	0.33	0.22	0.44	0.08	0.25
193	51	0.44	0.86	0.07	0.26	0.23	0.66	0.05	0.22	0.35	0.68	0.01	0.11	0.49	0.75	0.10	0.34
211	32	0.70	1.12	0.11	0.37	0.57	1.01	0.36	0.71	0.54	0.80	0.40	0.85	0.29	0.61	0.34	0.66
212	19	0.25	1.09	0.08	0.24	0.16	0.37	0.17	0.55	0.34	0.91	0.34	0.78	0.30	0.91	0.05	0.23
240	8	0.38	0.52	0.38	1.06	0.38	1.06	0.38	1.06	0.59	1.40	0.25	0.46	1.41	1.44	0.63	1.06
250	63	0.10	0.43	0.08	0.27	0.17	0.59	0.08	0.33	0.17	0.53	0.06	0.23	0.19	0.61	0.04	0.18
Overall[a]	2,931	0.57	0.04	0.25	0.02	0.43	0.03	0.24	0.01	0.52	0.03	0.25	0.02	0.46	0.02	0.29	0.02

[a] Overall means (M) and standard errors (SE)

Table D-4. Number of Existing Trees At Different Locations Projected for All Residential Units and Adjusted to the Medium-Sized Reference Tree.

SubRAD	N	NE	E	SE	S	SW	W	NW	Totals
12	82	82	0	0	0	0	0	82	245
21	1,433	1,095	1,792	1,254	2,628	1,413	856	1,314	11,785
22	470	407	720	783	1,065	595	710	668	5,418
23	1,478	1,021	841	925	1,382	469	1,057	949	8,122
31	3,601	1,913	6,835	928	6,048	675	6,723	1,294	28,017
32	9,560	0	4,238	1,478	8,377	2,957	5,864	986	33,460
33	70	26	78	52	87	52	0	52	417
41	2,498	380	2,118	1,385	2,633	624	1,195	1,222	12,054
42	1,311	444	756	271	1,110	493	1,117	451	5,952
43	4,393	1,500	4,393	1,447	4,340	1,848	4,179	2,223	24,324
44	2,930	1,119	2,650	1,399	4,559	1,613	2,699	1,169	18,139
51	2,488	1,336	2,211	1,382	3,056	2,626	4,207	1,658	18,964
52	3,070	972	1,668	1,621	2,936	1,640	2,107	1,525	15,540
61	1,747	1,338	897	1,731	1,354	1,842	1,763	1,542	12,214
62	180	314	314	359	314	135	0	674	2,291
63	846	2,069	752	329	2,069	1,646	329	282	8,323
71	82	327	572	0	491	164	82	0	1,717
73	2,402	1,880	3,499	1,410	2,925	2,455	3,447	1,358	19,376
74	215	0	0	0	0	0	0	0	215
81	3,489	763	2,980	1,308	3,017	1,817	3,053	3,417	19,845
82	8,006	4,342	6,785	5,745	7,147	2,714	7,373	4,342	46,454
83	3,219	767	1,329	749	1,647	449	2,302	468	10,930
84	461	542	217	190	624	298	1,030	81	3,443
91	1,839	1,329	3,390	1,152	2,105	1,041	2,615	1,617	15,089
92	6,906	1,570	4,590	1,228	4,611	1,832	4,288	2,637	27,663
93	6,852	3,942	4,128	4,415	5,430	6,073	5,211	3,959	40,010
94	9,105	4,155	5,569	5,171	8,088	2,696	8,132	4,022	46,937
100	7,358	4,245	7,358	5,490	9,339	4,302	10,641	6,792	55,526
111	1,419	587	1,150	328	2,123	587	1,854	680	8,728

SubRAD	N	NE	E	SE	S	SW	W	NW	Totals
112	5,695	2,417	3,917	1,250	4,195	1,917	4,611	1,611	25,612
121	5,332	2,247	2,046	1,777	4,561	1,140	3,689	2,247	23,037
122	4,083	2,794	4,360	7,215	3,162	2,364	5,342	6,816	36,136
123	1,580	718	0	1,364	1,364	503	1,077	1,867	8,473
124	656	0	715	0	1,610	0	0	179	3,159
131	239	399	0	80	80	0	0	319	1,117
133	688	55	509	0	454	55	701	55	2,516
134	1,376	116	1,575	697	2,106	265	547	299	6,982
135	1,524	737	1,189	670	1,524	972	988	1,072	8,677
136	1,400	0	350	0	200	0	0	0	1,950
137	925	254	936	243	798	763	1,191	636	5,745
141	8,630	6,516	4,990	11,154	8,454	7,925	7,397	8,512	63,578
142	1,879	613	1,397	241	2,351	231	1,789	382	8,882
143	2,529	2,222	2,387	2,458	3,143	2,860	3,025	2,813	21,437
144	2,372	2,944	2,801	1,486	2,801	3,458	3,029	3,544	22,435
145	2,287	897	1,838	762	2,108	852	3,184	3,094	15,022
151	5,010	2,219	4,330	5,583	2,505	6,227	5,404	4,652	35,931
152	3,797	506	1,476	1,139	2,362	844	1,350	506	11,980
153	5,894	3,107	10,325	3,015	6,944	2,604	13,386	1,919	47,194
161	4,046	1,363	6,937	1,280	4,377	1,528	6,565	1,363	27,457
162	2,042	1,594	3,585	996	2,042	598	3,038	1,295	15,189
163	2,254	852	1,152	1,052	1,603	902	3,657	301	11,771
164	3,224	2,695	2,791	4,187	4,860	2,454	2,550	2,310	25,071
170	1,752	0	438	0	1,168	584	730	219	4,891
181	1,330	760	570	1,282	1,425	142	1,282	1,900	8,691
191	175	28	249	0	415	111	222	37	1,237
192	576	242	121	0	242	121	242	91	1,636
193	2,624	442	1,356	324	2,093	88	2,919	619	10,467
211	2,673	416	2,168	1,366	2,050	1,515	1,099	1,307	12,594
212	280	88	177	191	382	382	338	59	1,898
240	497	497	497	497	787	331	1,863	828	5,797

SubRAD	N	NE	E	SE	S	SW	W	NW	Totals
250	853	656	1,444	624	1,411	492	1,608	328	7,417
Totals	165,729	76,859	138,460	93,465	163,080	85,283	165,658	96,643	985,177

Table D-5. Numbers of Existing Trees At Different Distances from Structures for the Sample, Projected for All Residential units, Adjusted to the Medium-Sized Reference Tree.

Sub-		Numbers for Sample			Projected for All Units			Adj. per Unit		Near per Unit		Far per Unit		Adjusted and Projected		
RAD	n	Adj.	Near	Far	Adj.	Near	Far	MAT	SD	MAT	SD	MAT	SD	Adj	Near	Far
12	12	0	2	1	0	163	82	0.00	0.00	1.00	0.00	0.50	0.71	0	163	82
21	32	69	59	18	5,494	4,698	1,433	2.27	2.55	1.86	2.23	0.50	1.14	5,773	4,738	1,274
22	29	38	51	22	1,587	2,130	919	1.62	2.26	2.00	2.17	0.85	1.81	1,963	2,422	1,034
23	51	63	67	18	3,028	3,220	865	1.49	1.78	1.45	2.22	0.38	0.87	3,652	3,544	925
31	87	163	58	10	18,340	6,526	1,125	1.97	1.73	0.77	1.20	0.13	0.48	19,240	7,539	1,238
32	62	95	24	7	18,726	4,731	1,380	2.15	1.86	0.45	0.89	0.14	0.56	26,315	5,470	1,675
33	4	8	4	3	278	139	104	1.63	1.44	0.81	1.07	0.56	1.13	226	113	78
41	94	97	17	4	10,534	1,846	434	0.93	1.16	0.21	0.57	0.04	0.20	9,502	2,118	434
42	120	146	39	13	4,052	1,082	361	1.23	1.50	0.41	1.05	0.15	0.52	4,086	1,381	486
43	104	138	43	15	14,787	4,608	1,607	1.38	1.47	0.54	0.96	0.26	0.85	15,430	6,001	2,893
44	113	122	79	7	8,033	5,201	461	1.37	1.77	1.00	1.39	0.06	0.31	10,222	7,456	461
51	69	81	100	40	4,975	6,142	2,457	1.61	1.78	2.00	2.20	0.86	1.80	6,833	8,476	3,655
52	133	207	120	31	7,894	4,576	1,182	1.71	1.68	1.09	1.54	0.26	0.68	8,666	5,549	1,325
61	48	115	29	15	7,240	1,826	944	2.86	3.34	0.89	1.79	0.29	0.80	8,641	2,691	881
62	16	11	0	3	1,977	0	539	0.63	1.23	0.00	0.00	0.17	0.49	1,797	0	494
63	25	25	6	0	4,702	1,128	0	1.31	1.91	0.46	1.00	0.00	0.00	6,160	2,163	0
71	3	11	3	0	1,199	327	0	4.42	4.38	0.83	1.44	0.00	0.00	1,444	273	0
73	41	69	22	13	14,414	4,596	2,716	1.40	1.38	0.62	0.95	0.24	0.73	11,960	5,327	2,089
74	1	1	0	0	286	0	0	0.75	0.00	0.00	0.00	0.00	0.00	215	0	0
81	31	53	50	29	7,706	7,269	4,216	1.56	1.22	1.74	2.23	1.10	1.95	7,051	7,851	4,943
82	57	103	97	39	18,636	17,550	7,056	1.95	1.98	1.84	2.07	0.71	1.46	20,128	18,952	7,373
83	22	38	39	44	2,845	2,920	3,294	1.59	1.30	2.11	2.01	2.93	3.43	2,620	3,481	4,829
84	11	18	7	5	1,952	759	542	1.84	2.10	0.59	0.48	0.45	0.69	2,196	705	542
91	43	89	39	26	7,888	3,456	2,304	2.28	1.92	1.03	1.35	0.65	0.86	8,686	3,922	2,482
92	88	177	86	25	14,255	6,926	2,013	2.30	1.67	1.25	1.66	0.35	0.91	16,328	8,879	2,456
93	121	352	135	56	23,820	9,135	3,789	3.00	1.99	1.30	1.60	0.59	1.33	24,530	10,675	4,805
94	52	134	63	40	23,690	11,138	7,072	2.68	1.89	1.47	2.23	0.96	1.80	24,618	13,524	8,795
100	69	127	54	14	28,754	12,226	3,170	2.31	2.30	1.00	1.96	0.24	0.61	36,112	15,679	3,736
111	53	115	20	10	5,396	938	469	2.41	1.72	0.69	1.48	0.41	1.73	5,995	1,724	1,009
112	69	163	22	22	18,112	2,445	2,445	2.51	1.83	0.38	0.86	0.45	1.15	19,251	2,889	3,472
121	75	86	33	3	11,535	4,426	402	1.57	1.54	0.63	1.11	0.09	0.49	15,761	6,371	905
122	78	114	59	6	14,000	7,246	737	2.36	2.45	1.29	2.02	0.13	0.52	22,566	12,342	1,228
123	24	22	9	0	6,319	2,585	0	0.82	0.87	0.41	0.81	0.00	0.00	5,672	2,800	0
124	9	6	3	1	1,431	715	238	0.83	1.14	0.31	0.46	0.33	1.00	1,788	656	715
131	4	6	4	0	479	319	0	2.50	2.08	1.00	1.15	0.00	0.00	798	319	0

Sub-		Numbers for Sample			Projected for All Units			Adj. per Unit		Near per Unit		Far per Unit		Adjusted and Projected		
RAD	n	Adj.	Near	Far	Adj.	Near	Far	MAT	SD	MAT	SD	MAT	SD	Adj	Near	Far
133	13	17	11	7	935	605	385	1.46	1.70	0.94	1.01	1.12	1.48	1,045	674	798
134	39	48	24	16	3,184	1,592	1,061	1.38	1.30	0.94	1.34	0.38	0.61	3,565	2,421	995
135	34	78	33	6	5,226	2,211	402	2.22	1.62	1.36	1.74	0.23	0.73	5,059	3,099	519
136	2	6	1	2	1,200	200	400	2.50	1.41	0.50	0.71	1.88	1.59	1,000	200	750
137	29	71	16	6	3,283	740	277	3.11	3.11	0.94	1.86	0.23	0.70	4,173	1,260	312
141	56	116	71	33	27,239	16,672	7,749	2.27	2.34	1.68	1.80	0.89	2.13	29,822	22,073	11,682
142	78	133	75	19	5,346	3,014	764	1.59	1.34	1.00	1.20	0.25	0.80	4,974	3,125	784
143	63	161	46	13	15,221	4,349	1,229	2.68	2.37	0.71	0.95	0.21	0.64	15,954	4,231	1,253
144	75	151	63	17	17,262	7,202	1,943	1.64	1.73	0.76	1.24	0.21	0.57	14,061	6,545	1,829
145	33	61	28	3	10,941	5,022	538	1.64	1.24	0.75	0.97	0.14	0.56	9,730	4,439	852
151	66	91	75	22	13,027	10,736	3,149	1.58	1.85	1.86	2.17	0.36	0.77	14,888	17,608	3,436
152	19	43	19	1	7,256	3,206	169	2.53	2.51	1.16	1.53	0.05	0.23	8,099	3,712	169
153	83	108	93	24	19,737	16,995	4,386	1.36	1.36	1.44	1.49	0.30	0.72	20,696	21,884	4,614
161	58	104	44	17	17,176	7,267	2,808	1.78	1.55	0.78	1.13	0.31	0.67	17,052	7,473	2,932
162	31	37	25	12	7,370	4,980	2,390	1.20	1.32	0.78	1.17	0.48	1.15	7,420	4,830	2,938
163	72	44	16	3	8,816	3,206	601	0.53	0.94	0.25	0.87	0.03	0.20	7,714	3,607	451
164	70	100	46	6	19,249	8,854	1,155	1.21	1.50	0.58	1.01	0.06	0.25	16,361	7,844	866
170	10	8	3	6	2,336	876	1,752	0.65	1.17	0.28	0.65	0.75	1.36	1,898	803	2,190
181	42	41	9	1	7,789	1,710	190	0.90	1.38	0.16	0.61	0.02	0.15	7,219	1,282	190
191	26	26	5	2	960	185	74	0.91	1.39	0.32	0.90	0.06	0.29	877	305	55
192	9	2	10	0	242	1,212	0	0.22	0.44	1.28	2.11	0.00	0.00	242	1,394	0
193	51	58	18	3	6,841	2,123	354	1.07	1.05	0.57	1.09	0.10	0.46	6,428	3,450	590
211	32	43	40	21	5,109	4,753	2,495	1.47	1.48	1.21	1.64	0.63	1.28	5,584	4,604	2,406
212	19	13	11	8	765	647	471	0.75	1.39	0.46	1.61	0.49	1.21	839	515	544
240	8	14	6	5	2,319	994	828	1.91	1.86	2.00	2.51	0.47	1.33	2,526	2,650	621
250	63	33	16	3	4,332	2,100	394	0.45	0.97	0.40	1.22	0.04	0.20	3,708	3,347	361
Totals	2,931	4,669	2,247	796	527,520	254,445	90,322	1.68[a]	0.06[b]	0.93[a]	0.04[b]	0.40[a]	0.03[b]	567,160	309,567	108,451

[a] Overall mean
[b] SE of overall mean

APPENDIX-E

Table E-1. Numbers of Potential Tree Sites for Different Sized Trees for the Sample, Projected for All Residential Units, and Adjusted to the Medium-Sized Reference Tree.

		Numbers for Sample			Projected for All Units			Adjusted and Projected		
SubRAD	n	Small	Medium	Large	Small	Medium	Large	MAT	SD	PAT
12	12	2	6	2	163	489	163	6.75	3.18	1,100
21	32	34	39	39	2,707	3,105	3,105	5.67	4.04	14,452
22	29	55	55	71	2,297	2,297	2,965	10.66	5.82	12,914
23	51	90	86	92	4,325	4,133	4,421	8.42	8.20	20,641
31	87	72	41	33	8,101	4,613	3,713	2.23	2.35	21,828
32	62	26	20	0	5,125	3,942	0	0.64	0.92	7,786
33	4	1	3	0	35	104	0	0.94	1.88	130
41	94	111	45	14	12,054	4,887	1,520	1.81	1.46	18,488
42	120	86	83	18	2,387	2,303	500	1.68	1.74	5,592
43	104	59	62	27	6,322	6,644	2,893	1.80	2.02	20,065
44	113	59	71	15	3,885	4,675	988	1.42	1.60	10,551
51	69	124	124	144	7,616	7,616	8,845	9.41	7.90	39,862
52	133	129	102	97	4,919	3,890	3,699	3.68	3.14	18,677
61	48	23	55	20	1,448	3,463	1,259	2.76	2.63	8,326
62	16	28	21	0	5,031	3,773	0	2.63	1.28	7,547
63	25	15	61	7	2,821	11,473	1,317	3.73	2.08	17,538
71	3	4	2	1	436	218	109	2.67	3.40	872
73	41	16	10	0	3,342	2,089	0	0.54	0.88	4,596
74	1	0	0	0	0	0	0	0.00	0.00	0
81	31	26	62	12	3,780	9,014	1,745	3.79	2.50	17,083
82	57	22	63	24	3,980	11,399	4,342	2.66	2.51	27,411
83	22	19	17	12	1,422	1,273	898	3.06	2.87	5,035
84	11	7	14	4	759	1,518	434	2.84	1.71	3,389
91	43	16	16	19	1,418	1,418	1,684	1.98	2.93	7,533
92	88	48	53	20	3,866	4,268	1,611	1.69	1.60	12,000
93	121	63	86	31	4,263	5,820	2,098	1.87	2.09	15,310
94	52	37	29	11	6,541	5,127	1,945	1.73	2.10	15,867
100	69	59	44	28	13,358	9,962	6,339	2.50	2.64	38,998

SubRAD	n	Numbers for Sample			Projected for All Units			Adjusted and Projected		
		Small	Medium	Large	Small	Medium	Large	MAT	SD	PAT
111	53	47	53	22	2,205	2,487	1,032	2.91	2.28	7,238
112	69	77	67	24	8,556	7,445	2,667	2.85	2.49	21,862
121	75	46	160	12	6,170	21,461	1,610	3.07	2.20	30,918
122	78	38	108	20	4,667	13,263	2,456	2.52	2.23	24,132
123	24	24	38	5	6,893	10,914	1,436	2.96	2.32	20,392
124	9	12	16	1	2,861	3,815	238	3.11	2.53	6,676
131	4	5	2	2	399	160	160	2.94	1.53	937
133	13	7	16	3	385	880	165	2.33	2.22	1,664
134	39	5	2	0	332	133	0	0.15	0.32	381
135	34	19	36	6	1,273	2,412	402	2.01	1.85	4,573
136	2	1	0	0	200	0	0	0.38	0.53	150
137	29	48	17	7	2,220	786	324	2.55	1.87	3,422
141	56	36	31	3	8,454	7,279	704	1.20	1.46	15,733
142	78	57	32	3	2,291	1,286	121	1.07	1.13	3,366
143	63	35	15	0	3,309	1,418	0	0.65	0.73	3,900
144	75	51	17	0	5,830	1,943	0	0.74	0.81	6,316
145	33	30	5	0	5,381	897	0	0.83	1.10	4,933
151	66	35	53	11	5,010	7,587	1,575	1.70	1.54	16,069
152	19	6	26	0	1,012	4,387	0	1.61	1.38	5,146
153	83	24	113	17	4,386	20,650	3,107	2.19	1.98	33,260
161	58	31	31	2	5,120	5,120	330	1.04	1.05	9,951
162	31	17	28	1	3,386	5,577	199	1.41	1.40	8,715
163	72	73	56	26	14,626	11,220	5,209	2.62	2.33	37,818
164	70	76	80	4	14,629	15,399	770	2.13	1.46	28,680
170	10	16	18	25	4,672	5,256	7,300	10.50	6.37	30,660
181	42	22	19	50	4,179	3,610	9,499	4.42	2.55	35,241
191	26	29	25	42	1,071	923	1,551	6.64	6.72	6,378
192	9	2	19	18	242	2,303	2,182	8.28	4.30	9,031
193	51	40	40	14	4,718	4,718	1,651	2.20	2.28	13,209
211	32	75	46	85	8,911	5,465	10,099	11.16	8.75	42,446

SubRAD	n	Numbers for Sample			Projected for All Units			Adjusted and Projected		
		Small	Medium	Large	Small	Medium	Large	MAT	SD	PAT
212	19	14	16	41	824	941	2,413	7.87	5.11	8,797
240	8	3	14	5	497	2,319	828	3.91	2.93	5,176
250	63	138	42	11	18,115	5,513	1,444	2.83	2.47	23,432
Totals	2,931	2,370	2,511	1,201	265,227	297,081	116,063	3.15[a]	0.09[b]	844,192

[a] Overall mean
[b] Standard error of the overall mean.

Table E-2. Number of Potential Tree Sites At Different Directions Around Sample Structures and for all Residential Units.

Sub	Numbers for the Sample								Projected for All Residential Units							
RAD	N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW
12	1	0	3	0	2	2	2	0	82	0	245	0	163	163	163	0
21	18	5	19	13	12	11	25	9	1,433	398	1,513	1,035	956	876	1,991	717
22	22	17	31	19	31	12	24	25	919	710	1,295	793	1,295	501	1,002	1,044
23	40	25	40	29	43	28	36	27	1,922	1,201	1,922	1,394	2,067	1,346	1,730	1,298
31	42	7	30	6	29	5	18	9	4,726	788	3,376	675	3,263	563	2,025	1,013
32	7	4	11	2	8	1	10	3	1,380	788	2,168	394	1,577	197	1,971	591
33	1	0	1	1	0	0	1	0	35	0	35	35	0	0	35	0
41	37	17	16	11	30	10	25	24	4,018	1,846	1,738	1,195	3,258	1,086	2,715	2,606
42	43	14	31	8	27	12	32	20	1,193	389	860	222	749	333	888	555
43	35	16	13	7	24	10	23	20	3,750	1,714	1,393	750	2,572	1,072	2,465	2,143
44	36	19	19	11	28	11	10	11	2,370	1,251	1,251	724	1,844	724	658	724
51	80	47	50	34	65	36	33	47	4,914	2,887	3,071	2,088	3,992	2,211	2,027	2,887
52	72	27	46	33	67	26	37	20	2,746	1,030	1,754	1,258	2,555	992	1,411	763
61	14	7	11	14	13	8	13	18	881	441	693	881	818	504	818	1,133
62	5	5	5	4	7	5	10	8	898	898	898	719	1,258	898	1,797	1,438
63	12	4	14	3	11	9	18	12	2,257	752	2,633	564	2,069	1,693	3,385	2,257
71	0	2	1	2	0	1	1	0	0	218	109	218	0	109	109	0
73	4	3	6	1	4	2	3	3	836	627	1,253	209	836	418	627	627
74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	23	9	8	2	26	9	17	6	3,344	1,308	1,163	291	3,780	1,308	2,472	872
82	24	7	19	10	22	8	11	8	4,342	1,267	3,438	1,809	3,980	1,447	1,990	1,447
83	13	1	6	0	21	2	4	1	973	75	449	0	1,572	150	299	75
84	9	5	3	1	3	4	0	0	976	542	325	108	325	434	0	0
91	7	5	14	5	5	2	8	5	620	443	1,241	443	443	177	709	443
92	33	4	16	4	29	6	23	6	2,658	322	1,289	322	2,335	483	1,852	483
93	30	25	22	23	34	11	17	18	2,030	1,692	1,489	1,556	2,301	744	1,150	1,218
94	20	8	9	4	17	7	5	7	3,536	1,414	1,591	707	3,005	1,238	884	1,238
100	44	8	17	8	24	9	10	11	9,962	1,811	3,849	1,811	5,434	2,038	2,264	2,490
111	33	9	25	9	17	14	12	3	1,549	422	1,173	422	798	657	563	141
112	38	14	29	13	29	12	18	15	4,222	1,556	3,222	1,445	3,222	1,333	2,000	1,667
121	46	10	36	15	38	18	36	19	6,170	1,341	4,829	2,012	5,097	2,414	4,829	2,549
122	25	13	29	13	12	21	27	26	3,070	1,597	3,561	1,597	1,474	2,579	3,316	3,193
123	22	2	7	4	18	4	7	3	6,319	574	2,010	1,149	5,170	1,149	2,010	862

Sub	Numbers for the Sample								Projected for All Residential Units							
RAD	N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW
124	12	1	0	0	12	0	1	3	2,861	238	0	0	2,861	0	238	715
131	1	2	2	0	0	3	1	0	80	160	160	0	0	239	80	0
133	3	3	2	1	12	0	4	1	165	165	110	55	660	0	220	55
134	3	0	2	0	2	0	0	0	199	0	133	0	133	0	0	0
135	23	3	6	6	15	2	3	3	1,541	201	402	402	1,005	134	201	201
136	1	0	0	0	0	0	0	0	200	0	0	0	0	0	0	0
137	23	12	7	0	11	1	12	6	1,064	555	324	0	509	46	555	277
141	15	8	6	12	14	4	3	8	3,522	1,879	1,409	2,818	3,288	939	704	1,879
142	30	7	11	4	19	6	10	5	1,206	281	442	161	764	241	402	201
143	7	5	17	4	3	3	6	5	662	473	1,607	378	284	284	567	473
144	15	8	8	10	8	7	4	8	1,715	915	915	1,143	915	800	457	915
145	994	3	10	1	5	3	5	4	717	538	1,794	179	897	538	897	717
151	11	22	15	9	9	10	16	7	1,575	3,149	2,147	1,288	1,288	1,432	2,290	1,002
152	2	4	7	3	5	1	9	1	337	675	1,181	506	844	169	1,519	169
153	34	7	32	3	24	5	45	4	6,213	1,279	5,848	548	4,386	914	8,224	731
161	12	1	19	0	9	4	15	4	1,982	165	3,138	0	1,486	661	2,477	661
162	10	4	10	0	11	2	8	1	1,992	797	1,992	0	2,191	398	1,594	199
163	37	11	28	12	31	7	21	8	7,413	2,204	5,610	2,404	6,211	1,403	4,208	1,603
164	33	14	15	19	27	16	13	23	6,352	2,695	2,887	3,657	5,197	3,080	2,502	4,427
170	6	4	13	5	9	6	10	6	1,752	1,168	3,796	1,460	2,628	1,752	2,920	1,752
181	24	7	11	7	18	7	10	7	4,559	1,330	2,090	1,330	3,420	1,330	1,900	1,330
191	18	10	18	6	18	8	12	6	665	369	665	222	665	295	443	222
192	5	4	7	5	5	5	3	5	606	485	849	606	606	606	364	606
193	14	3	26	8	21	5	12	5	1,651	354	3,066	944	2,477	590	1,415	590
211	38	27	17	23	31	22	16	32	4,515	3,208	2,020	2,733	3,683	2,614	1,901	3,802
212	23	7	9	5	14	3	5	5	1,353	412	530	294	824	177	294	294
240	0	2	5	2	6	1	4	2	0	331	828	331	994	166	663	331
250	39	16	31	12	42	12	25	14	5,120	2,100	4,069	1,575	5,513	1,575	3,282	1,838
Total	1,279	534	921	466	1,077	459	789	557	144,148	56,429	103,846	49,863	121,934	50,218	90,473	61,461

Table E-3. Mean Number of Potential Tree Sites At Different Directions Per Residential Unit When Adjusted to the Medium-Sized Reference Tree and Standard Deviations.

Sub-	n	N		NE		E		SE		S		SW		W		NW	
RAD		MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD
12	12	0.50	0.71	0.00	0.00	1.25	0.35	0.00	0.00	2.00	1.41	1.00	0.00	2.00	1.41	0.00	0.00
21	32	0.91	1.50	0.28	0.77	0.98	1.44	0.76	1.29	0.59	1.00	0.50	1.20	1.16	1.23	0.51	1.08
22	29	1.48	1.49	1.31	1.51	1.82	1.97	1.10	1.52	1.75	2.23	0.79	1.22	1.29	1.31	1.11	1.47
23	51	1.37	1.92	0.74	1.27	1.17	1.84	0.96	1.63	1.60	2.14	0.82	1.41	0.98	1.32	0.80	1.58
31	87	0.72	1.09	0.09	0.38	0.36	0.66	0.07	0.25	0.50	1.14	0.09	0.47	0.24	0.71	0.16	0.58
32	62	0.10	0.29	0.05	0.20	0.16	0.42	0.02	0.13	0.11	0.32	0.01	0.10	0.15	0.44	0.04	0.16
33	4	0.25	0.50	0.00	0.00	0.19	0.38	0.25	0.50	0.00	0.00	0.00	0.00	0.25	0.50	0.00	0.00
41	94	0.35	0.63	0.18	0.49	0.18	0.62	0.10	0.35	0.36	0.74	0.09	0.28	0.29	0.64	0.27	0.66
42	120	0.39	0.86	0.13	0.47	0.26	0.61	0.10	0.43	0.19	0.48	0.13	0.47	0.32	0.75	0.16	0.44
43	104	0.33	0.65	0.22	0.65	0.18	0.72	0.06	0.26	0.29	0.67	0.14	0.58	0.30	0.72	0.29	0.83
44	113	0.31	0.60	0.24	0.74	0.17	0.46	0.09	0.34	0.32	0.82	0.10	0.47	0.10	0.37	0.09	0.34
51	69	1.93	1.97	1.04	1.83	1.29	1.84	0.80	1.33	1.44	2.17	0.82	1.58	0.84	1.60	1.24	2.06
52	133	0.89	1.62	0.29	0.80	0.55	1.20	0.39	1.16	0.69	1.30	0.24	0.76	0.40	0.91	0.23	0.68
61	48	0.36	0.73	0.18	0.56	0.29	0.75	0.53	1.23	0.42	0.94	0.20	0.57	0.34	0.72	0.43	0.74
62	16	0.25	0.39	0.27	0.62	0.25	0.47	0.23	0.42	0.38	0.61	0.27	0.41	0.53	0.44	0.45	0.48
63	25	0.68	1.20	0.15	0.46	0.68	1.03	0.12	0.33	0.51	0.82	0.34	0.72	0.72	0.89	0.53	0.84
71	3	0.00	0.00	1.33	2.31	0.25	0.43	0.58	0.52	0.00	0.00	0.25	0.43	0.25	0.43	0.00	0.00
73	41	0.07	0.28	0.07	0.24	0.12	0.30	0.02	0.12	0.09	0.28	0.05	0.22	0.05	0.20	0.06	0.22
74	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
81	31	0.73	1.01	0.34	0.82	0.26	0.58	0.19	0.75	0.93	1.33	0.48	1.03	0.60	1.02	0.26	0.68
82	57	0.58	1.16	0.15	0.50	0.37	0.79	0.20	0.53	0.51	0.97	0.28	0.80	0.29	0.73	0.27	0.79
83	22	0.80	1.20	0.03	0.16	0.24	0.56	0.00	0.00	1.40	2.36	0.18	0.66	0.36	1.05	0.05	0.21
84	11	1.14	1.19	0.43	0.50	0.43	1.20	0.09	0.30	0.43	1.00	0.32	0.84	0.00	0.00	0.00	0.00
91	43	0.34	0.89	0.20	0.66	0.53	1.30	0.16	0.56	0.20	0.68	0.04	0.19	0.31	0.89	0.20	0.74
92	88	0.40	0.78	0.04	0.19	0.26	0.67	0.04	0.17	0.45	0.83	0.07	0.24	0.37	0.83	0.08	0.37
93	121	0.27	0.61	0.24	0.66	0.21	0.65	0.24	0.74	0.46	1.08	0.13	0.51	0.14	0.46	0.17	0.58
94	52	0.40	0.88	0.14	0.38	0.27	0.74	0.06	0.20	0.36	0.77	0.16	0.58	0.13	0.48	0.21	1.01
100	69	0.82	1.26	0.10	0.35	0.31	0.72	0.17	0.72	0.51	1.23	0.14	0.49	0.22	0.69	0.23	0.70
111	53	0.68	0.90	0.23	0.63	0.69	1.38	0.18	0.49	0.42	0.85	0.41	1.04	0.25	0.60	0.05	0.20
112	69	0.64	0.86	0.17	0.43	0.49	0.93	0.20	0.51	0.53	0.97	0.22	0.58	0.40	1.03	0.21	0.54
121	75	0.55	0.86	0.15	0.51	0.54	0.89	0.22	0.63	0.49	0.85	0.31	0.72	0.49	0.89	0.31	0.82
122	78	0.30	0.75	0.23	0.70	0.40	0.87	0.24	0.77	0.23	0.66	0.33	0.82	0.43	1.07	0.35	0.76
123	24.00	0.79	1.10	0.08	0.28	0.28	0.54	0.15	0.34	0.88	1.30	0.16	0.47	0.42	0.89	0.21	0.66

Sub-RAD	n	N		NE		E		SE		S		SW		W		NW	
		MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD	MAT	SD
124	9	1.39	1.66	0.11	0.33	0.00	0.00	0.00	0.00	1.22	1.22	0.00	0.00	0.08	0.25	0.31	0.46
131	4	0.19	0.38	0.38	0.43	0.94	1.42	0.00	0.00	0.00	0.00	1.25	1.89	0.19	0.38	0.00	0.00
133	13	0.38	1.12	0.37	0.86	0.31	0.85	0.08	0.28	0.88	1.12	0.00	0.00	0.25	0.90	0.06	0.21
134	39	0.06	0.23	0.00	0.00	0.04	0.20	0.00	0.00	0.04	0.17	0.00	0.00	0.00	0.00	0.00	0.00
135	34	0.60	0.96	0.08	0.27	0.16	0.48	0.17	0.43	0.71	1.14	0.05	0.21	0.08	0.27	0.15	0.70
136	2	0.38	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
137	29	0.82	1.09	0.39	0.71	0.20	0.53	0.00	0.00	0.55	1.13	0.03	0.14	0.41	0.87	0.16	0.31
141	56	0.27	0.60	0.12	0.30	0.13	0.53	0.19	0.45	0.21	0.45	0.10	0.45	0.04	0.22	0.13	0.38
142	78	0.33	0.50	0.08	0.25	0.12	0.29	0.04	0.20	0.26	0.63	0.07	0.24	0.13	0.41	0.05	0.21
143	63	0.10	0.34	0.07	0.23	0.21	0.43	0.06	0.22	0.04	0.18	0.04	0.16	0.08	0.30	0.06	0.22
144	75	0.16	0.38	0.09	0.26	0.09	0.27	0.11	0.32	0.08	0.23	0.07	0.23	0.05	0.20	0.09	0.26
145	33	0.09	0.25	0.07	0.22	0.23	0.36	0.02	0.13	0.12	0.35	0.07	0.29	0.12	0.29	0.11	0.29
151	66	0.25	0.77	0.34	0.72	0.24	0.59	0.11	0.39	0.16	0.50	0.13	0.36	0.31	0.75	0.16	0.56
152	19	0.11	0.32	0.18	0.61	0.37	0.76	0.16	0.37	0.26	0.56	0.05	0.23	0.42	0.67	0.05	0.23
153	83	0.55	1.10	0.08	0.32	0.44	0.96	0.06	0.36	0.38	0.81	0.08	0.41	0.55	0.97	0.05	0.24
161	58	0.19	0.54	0.02	0.13	0.33	0.69	0.00	0.00	0.13	0.33	0.06	0.21	0.23	0.46	0.09	0.46
162	31	0.29	0.54	0.10	0.28	0.30	0.50	0.00	0.00	0.40	0.94	0.06	0.25	0.23	0.45	0.02	0.13
163	72	0.55	0.70	0.22	0.65	0.44	0.93	0.26	0.72	0.48	0.83	0.14	0.81	0.37	0.86	0.16	0.54
164	70	0.42	0.56	0.18	0.45	0.22	0.50	0.23	0.57	0.39	0.75	0.21	0.44	0.20	0.52	0.29	0.55
170	10	0.93	1.40	0.58	0.96	2.00	1.31	1.10	1.37	1.85	2.08	1.40	2.01	1.48	1.27	1.18	1.32
181	42	1.05	1.41	0.35	0.90	0.54	1.08	0.30	0.95	1.03	1.49	0.24	0.71	0.57	1.25	0.35	0.98
191	26	1.25	1.25	0.91	1.32	1.50	2.09	0.46	0.99	0.90	1.15	0.44	0.85	0.82	1.29	0.36	0.83
192	9	1.00	1.32	0.64	0.99	1.89	1.36	1.00	1.22	1.44	1.74	1.00	1.22	0.56	1.01	0.75	1.06
193	51	0.29	0.61	0.09	0.45	0.68	1.14	0.23	0.64	0.45	0.82	0.13	0.48	0.25	0.56	0.08	0.24
211	32	1.83	1.85	1.77	2.19	0.99	1.78	1.02	1.73	1.89	1.83	1.12	1.76	0.95	1.41	1.59	2.08
212	19	2.63	2.56	0.54	1.12	0.87	1.43	0.46	1.23	1.97	1.86	0.37	1.12	0.58	1.17	0.45	1.14
240	8	0.00	0.00	0.50	1.07	0.88	1.13	0.25	0.46	0.91	1.16	0.13	0.35	1.00	1.60	0.25	0.46
250	63	0.57	0.75	0.31	0.71	0.43	0.70	0.23	0.63	0.57	0.73	0.19	0.50	0.32	0.55	0.22	0.53
Overall[a]	2,931	0.59	0.03	0.29	0.03	0.49	0.03	0.24	0.02	0.60	0.03	0.27	0.02	0.41	0.03	0.26	0.02

[a] Overall means (M) and standard errors (SE)

Table E-4. Number of Potential Tree Sites At Different Locations Projected for All Residential Units and Adjusted to the Medium-Sized Reference Tree.

SubRAD	N	NE	E	SE	S	SW	W	NW	Totals
12	82	0	204	0	326	163	326	0	1,100
21	2,309	717	2,488	1,931	1,493	1,274	2,946	1,294	14,452
22	1,796	1,587	2,203	1,336	2,119	960	1,566	1,347	12,914
23	3,352	1,802	2,860	2,355	3,917	2,006	2,391	1,958	20,641
31	7,004	900	3,516	647	4,866	928	2,391	1,575	21,828
32	1,232	641	1,922	296	1,331	148	1,774	444	7,786
33	35	0	26	35	0	0	35	0	130
41	3,529	1,846	1,846	977	3,665	896	2,932	2,796	18,488
42	1,297	437	853	326	638	423	1,068	548	5,592
43	3,643	2,411	1,982	697	3,241	1,554	3,322	3,215	20,065
44	2,272	1,761	1,267	691	2,370	757	741	691	10,551
51	8,200	4,392	5,466	3,393	6,111	3,470	3,562	5,267	39,862
52	4,538	1,449	2,812	1,993	3,499	1,220	2,012	1,154	18,677
61	1,102	535	866	1,605	1,275	614	1,039	1,291	8,326
62	719	764	719	674	1,078	764	1,527	1,303	7,547
63	3,197	705	3,197	564	2,398	1,599	3,385	2,492	17,538
71	0	436	82	191	0	82	82	0	872
73	627	574	1,045	157	783	418	470	522	4,596
74	0	0	0	0	0	0	0	0	0
81	3,308	1,527	1,163	872	4,180	2,144	2,726	1,163	17,083
82	5,971	1,538	3,845	2,035	5,292	2,895	3,031	2,804	27,411
83	1,310	56	393	0	2,302	299	599	75	5,035
84	1,356	515	515	108	515	380	0	0	3,389
91	1,307	753	2,016	598	753	155	1,196	753	7,533
92	2,859	282	1,812	262	3,161	463	2,597	564	12,000
93	2,182	1,962	1,759	1,979	3,739	1,100	1,167	1,421	15,310
94	3,713	1,282	2,519	530	3,271	1,459	1,193	1,900	15,867
100	12,735	1,585	4,811	2,604	8,037	2,264	3,396	3,566	38,998
111	1,701	563	1,713	446	1,056	1,021	622	117	7,238
112	4,889	1,278	3,750	1,500	4,056	1,667	3,083	1,639	21,862
121	5,533	1,543	5,466	2,247	4,963	3,119	4,929	3,119	30,918
122	2,886	2,241	3,807	2,303	2,211	3,193	4,145	3,347	24,132
123	5,457	574	1,939	1,005	6,031	1,077	2,872	1,436	20,392
124	2,981	238	0	0	2,623	0	179	656	6,676

SubRAD	N	NE	E	SE	S	SW	W	NW	Totals
131	60	120	299	0	0	399	60	0	937
133	275	261	220	55	633	0	179	41	1,664
134	166	0	116	0	100	0	0	0	381
135	1,374	184	369	385	1,625	117	184	335	4,573
136	150	0	0	0	0	0	0	0	150
137	1,098	520	266	0	740	35	555	208	3,422
141	3,522	1,585	1,761	2,466	2,818	1,350	528	1,702	15,733
142	1,025	241	362	141	814	211	402	171	3,366
143	567	402	1,276	331	236	213	496	378	3,900
144	1,372	743	772	972	686	629	400	743	6,316
145	538	404	1,390	135	717	404	717	628	4,932
151	2,398	3,221	2,255	1,074	1,503	1,217	2,899	1,503	16,069
152	337	591	1,181	506	844	169	1,350	169	5,146
153	8,361	1,279	6,670	914	5,711	1,234	8,406	685	33,260
161	1,775	165	3,179	0	1,197	537	2,188	908	9,951
162	1,793	647	1,843	0	2,490	398	1,394	149	8,715
163	7,914	3,206	6,412	3,807	6,963	1,954	5,310	2,254	37,818
164	5,678	2,358	2,984	3,080	5,197	2,791	2,743	3,850	28,680
170	2,701	1,679	5,840	3,212	5,402	4,088	4,307	3,431	30,660
181	8,359	2,755	4,274	2,422	8,216	1,947	4,512	2,755	35,241
191	1,200	877	1,440	443	868	425	785	342	6,378
192	1,091	697	2,061	1,091	1,576	1,091	606	818	9,031
193	1,740	560	4,098	1,356	2,713	767	1,504	472	13,209
211	6,951	6,743	3,772	3,891	7,188	4,248	3,624	6,030	42,446
212	2,942	603	971	515	2,207	412	647	500	8,797
240	0	663	1,159	331	1,201	166	1,325	331	5,176
250	4,693	2,527	3,544	1,871	4,726	1,608	2,658	1,805	23,432
Totals	171,200	69,925	127,377	63,354	157,670	64,917	111,085	78,665	844,192

Table E-5. Numbers of Potential Tree Sites At Different Distances from Single Family Residences for the Sample, Projected for All Residences, and Adjusted to the Medium-Sized Reference Tree.

Sub-		Numbers for Sample			Projected for All Units			Adj./Units		Near/Units		Far/Units		Adjusted and Projected			
RAD	n	Adj.	Near	Far	Adj.	Near	Far	MAT	SD	MAT	SD	MAT	SD	Adj.	Near	Far	Total
12	12	7	3	0	571	245	0	3.25	0.35	3.50	3.54	0.00	0.00	530	571	0	1,100
21	32	77	31	4	6,131	2,468	319	4.32	3.40	1.17	1.75	0.18	0.58	11,008	2,986	458	14,452
22	29	71	49	61	2,965	2,046	2,547	4.96	2.84	2.44	2.40	3.27	3.57	6,003	2,954	3,957	12,914
23	51	100	61	107	4,806	2,932	5,142	3.79	3.65	1.81	2.45	2.81	3.99	9,299	4,445	6,896	20,641
31	87	114	26	6	12,827	2,925	675	1.86	2.04	0.29	0.62	0.08	0.37	18,172	2,869	788	21,828
32	62	28	13	5	5,519	2,562	986	0.39	0.75	0.18	0.49	0.06	0.22	4,780	2,218	788	7,786
33	4	0	3	1	0	104	35	0.00	0.00	0.69	1.38	0.25	0.50	0	96	35	130
41	94	145	20	5	15,746	2,172	543	1.39	1.35	0.31	0.81	0.12	0.55	14,172	3,122	1,195	18,488
42	120	158	21	8	4,385	583	222	1.36	1.48	0.21	0.68	0.11	0.56	4,523	687	382	5,592
43	104	110	22	16	11,787	2,357	1,714	1.17	1.55	0.36	0.88	0.28	1.00	12,992	3,991	3,081	20,065
44	113	88	51	6	5,794	3,358	395	0.87	1.23	0.50	0.84	0.05	0.26	6,436	3,720	395	10,551
51	69	138	90	164	8,476	5,528	10,073	4.01	3.66	1.87	1.99	3.53	4.09	16,983	7,908	14,971	39,862
52	133	182	69	77	6,941	2,631	2,936	2.41	2.31	0.58	1.00	0.69	1.56	12,232	2,955	3,489	18,677
61	48	81	9	8	5,100	567	504	2.14	2.01	0.29	0.76	0.33	1.74	6,453	881	992	8,326
62	16	48	0	1	8,625	0	180	2.56	1.25	0.00	0.00	0.06	0.25	7,367	0	180	7,547
63	25	50	30	3	9,404	5,642	564	2.18	1.61	1.43	1.51	0.12	0.33	10,250	6,724	564	17,538
71	3	4	2	1	436	218	109	1.08	1.28	0.58	0.52	1.00	1.73	354	191	327	872
73	41	17	8	1	3,551	1,671	209	0.33	0.57	0.18	0.67	0.02	0.16	2,820	1,567	209	4,596
74	1	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0
81	31	41	43	16	5,961	6,252	2,326	1.11	1.14	1.71	1.62	0.97	1.52	5,016	7,706	4,362	17,083
82	57	53	40	16	9,589	7,237	2,895	0.83	1.11	1.30	1.51	0.53	1.17	8,594	13,389	5,428	27,411
83	22	25	14	9	1,872	1,048	674	1.06	0.94	0.95	1.30	1.05	1.99	1,741	1,572	1,722	5,035
84	11	10	8	7	1,085	868	759	0.77	0.70	0.70	0.78	1.36	1.57	922	841	1,627	3,389
91	43	33	12	6	2,925	1,064	532	1.23	1.41	0.43	1.15	0.32	1.10	4,675	1,640	1,219	7,533
92	88	87	24	10	7,006	1,933	805	1.13	1.16	0.42	0.93	0.14	0.52	7,973	3,000	1,027	12,000
93	121	132	30	18	8,932	2,030	1,218	1.27	1.29	0.40	1.03	0.20	0.68	10,370	3,282	1,658	15,310
94	52	50	18	9	8,839	3,182	1,591	1.01	1.21	0.51	1.07	0.20	0.57	9,326	4,729	1,812	15,867
100	69	81	32	18	18,339	7,245	4,075	1.74	1.80	0.45	0.94	0.32	0.84	27,112	6,962	4,924	38,998
111	53	97	14	11	4,552	657	516	1.88	1.81	0.60	1.41	0.43	1.32	4,669	1,502	1,068	7,238
112	69	145	13	10	16,112	1,445	1,111	2.30	2.21	0.29	0.80	0.25	0.79	17,667	2,250	1,945	21,862
121	75	144	65	9	19,315	8,719	1,207	1.84	1.44	1.07	1.41	0.16	0.56	18,510	10,798	1,610	30,918
122	78	95	62	9	11,667	7,614	1,105	1.23	1.35	1.10	1.45	0.19	0.79	11,820	10,531	1,781	24,132
123	24	44	20	3	12,637	5,744	862	1.83	1.21	0.92	1.38	0.21	0.66	12,637	6,319	1,436	20,392
124	9	17	7	5	4,054	1,669	1,192	1.64	1.40	1.00	1.32	0.47	0.94	3,517	2,146	1,013	6,676
131	4	8	1	0	638	80	0	2.19	1.57	0.75	1.50	0.00	0.00	698	239	0	937

Sub-RAD	n	Numbers for Sample			Projected for All Units			Adj./Units		Near/Units		Far/Units		Adjusted and Projected			Total
		Adj.	Near	Far	Adj.	Near	Far	MAT	SD	MAT	SD	MAT	SD	Adj.	Near	Far	
133	13	14	6	6	770	330	330	1.29	1.33	0.42	0.76	0.62	1.39	921	303	440	1,664
134	39	0	5	2	0	332	133	0.00	0.00	0.11	0.29	0.04	0.17	0	282	100	381
135	34	44	14	3	2,948	938	201	1.35	1.34	0.51	0.81	0.14	0.59	3,082	1,173	318	4,573
136	2	1	0	0	200	0	0	0.38	0.53	0.00	0.00	0.00	0.00	150	0	0	150
137	29	62	7	3	2,867	324	139	1.86	1.69	0.38	0.98	0.31	0.93	2,497	509	416	3,422
141	56	54	11	5	12,680	2,583	1,174	0.83	1.23	0.25	0.62	0.13	0.47	10,860	3,229	1,644	15,733
142	78	61	26	5	2,452	1,045	201	0.63	0.64	0.36	0.70	0.08	0.38	1,979	1,135	251	3,366
143	63	34	14	2	3,214	1,324	189	0.43	0.58	0.20	0.38	0.02	0.13	2,576	1,182	142	3,900
144	75	45	23	0	5,144	2,629	0	0.47	0.55	0.27	0.56	0.00	0.00	4,030	2,286	0	6,316
145	33	25	8	2	4,484	1,435	359	0.59	1.12	0.20	0.36	0.05	0.26	3,498	1,166	269	4,933
151	66	63	26	10	9,019	3,722	1,432	0.94	1.19	0.51	1.01	0.25	0.75	8,875	4,796	2,398	16,069
152	19	19	13	0	3,206	2,194	0	0.93	1.12	0.67	0.91	0.00	0.00	2,995	2,151	0	5,146
153	83	121	23	10	22,112	4,203	1,827	1.56	1.42	0.39	0.91	0.24	0.96	23,666	5,985	3,609	33,260
161	58	51	10	3	8,423	1,652	495	0.81	0.83	0.15	0.34	0.08	0.42	7,721	1,445	784	9,951
162	31	34	9	3	6,773	1,793	598	0.99	1.01	0.32	0.78	0.10	0.30	6,125	1,992	598	8,715
163	72	116	29	10	23,242	5,810	2,004	1.81	1.47	0.58	1.41	0.24	0.76	26,097	8,315	3,406	37,818
164	70	125	28	7	24,061	5,390	1,347	1.62	1.19	0.39	0.81	0.12	0.46	21,847	5,245	1,588	28,680
170	10	29	18	12	8,468	5,256	3,504	3.10	4.25	4.00	3.92	3.40	5.25	9,052	11,680	9,928	30,660
181	42	81	9	1	15,388	1,710	190	4.16	2.45	0.24	0.68	0.02	0.12	33,198	1,900	142	35,241
191	26	73	23	0	2,695	849	0	4.23	5.22	2.41	5.63	0.00	0.00	4,062	2,317	0	6,378
192	9	3	26	10	364	3,152	1,212	0.28	0.42	6.00	3.91	2.00	3.54	303	6,546	2,182	9,031
193	51	74	16	4	8,728	1,887	472	1.30	1.37	0.66	1.46	0.24	1.32	7,814	3,981	1,415	13,209
211	32	84	55	67	9,980	6,535	7,960	5.73	3.67	2.58	3.35	2.86	4.25	21,772	9,802	10,871	42,446
212	19	42	11	18	2,471	647	1,059	5.53	2.45	0.83	1.38	1.51	3.62	6,178	927	1,692	8,797
240	8	7	14	1	1,159	2,319	166	0.78	0.94	2.75	2.38	0.38	1.06	1,035	3,644	497	5,176
250	63	150	40	1	19,690	5,251	131	1.86	1.32	0.93	2.32	0.05	0.38	15,359	7,679	394	23,432
Total	2,931	3,892	1,375	815	447,124	158,103	73,145	1.71[a]	0.06[b]	0.90[a]	0.03[b]	0.53[a]	0.05[b]	515,316	214,457	114,420	844,192

[a] Overall mean
[b] SE of overall mean

APPENDIX F

Table F. Number of Potential Tree Sites Using Sacramento Shade Siting Guidelines.

Sub-RAD	n	Total Units	Projected by Tree Size			Adjusted/Unit		Total Sites	Adjusted and Projected by Direction						
			Small	Med	Large	MAT	SD		NE	E	SE	S	SW	W	NW
12	2	163	163	408	163	6.25	2.47	1,019	0	204	0	326	163	326	0
21	32	2,548	2,309	2,389	2,548	4.62	3.71	11,765	717	2,488	1,851	1,433	1,035	2,946	1,294
22	29	1,211	1,462	1,086	1,754	6.15	4.13	7,443	856	1,670	606	1,472	668	1,399	773
23	51	2,451	2,259	1,586	2,595	4.51	4.56	11,066	973	2,030	997	3,028	1,105	1,934	997
31	87	9,789	6,188	2,813	2,250	1.45	1.89	14,205	900	3,432	647	4,754	928	2,307	1,238
32	62	12,221	3,745	2,957	0	0.47	0.83	5,766	641	1,626	296	1,331	148	1,577	148
33	4	139	35	35	0	0.44	0.88	61	0	26	0	0	0	35	0
41	94	10,208	9,231	3,584	1,086	1.35	1.42	13,765	1,520	1,520	977	3,339	787	2,823	2,796
42	120	3,330	1,915	1,637	361	1.25	1.49	4,156	409	770	326	638	423	1,041	548
43	104	11,144	3,965	4,822	1,929	1.22	1.59	13,582	1,768	1,447	589	2,598	1,473	3,000	2,706
44	113	7,440	2,963	2,963	922	1.07	1.39	7,950	1,695	1,202	625	2,370	691	675	691
51	69	4,238	3,071	3,071	4,299	4.31	4.32	18,273	1,750	4,161	1,873	4,699	1,259	2,564	1,965
52	133	5,072	2,822	2,364	2,326	2.26	2.28	11,460	1,106	2,345	1,344	3,118	1,011	1,726	810
61	48	3,022	1,259	2,644	881	2.06	2.01	6,233	535	677	1,102	1,228	614	976	1,102
62	16	2,875	4,313	3,414	0	2.31	1.20	6,648	584	719	674	1,078	764	1,527	1,303
63	25	4,702	2,069	9,968	752	2.93	1.94	13,777	705	3,009	564	2,398	1,599	3,197	2,304
71	3	327	436	218	0	1.67	1.76	545	109	82	191	0	82	82	0
73	41	8,565	2,507	1,880	0	0.44	0.78	3,760	574	1,045	157	783	209	470	522
74	1	286	0	0	0	0.00	0.00	0	0	0	0	0	0	0	0
81	31	4,507	2,472	6,106	727	2.25	1.78	10,141	945	1,163	872	2,871	1,127	2,144	1,018
82	57	10,313	3,257	7,599	2,714	1.76	1.78	18,183	1,538	3,664	1,855	4,388	1,628	2,850	2,262
83	22	1,647	973	898	225	1.40	1.48	2,302	56	393	0	1,104	299	374	75
84	11	1,193	542	868	0	1.07	1.01	1,274	515	190	0	190	380	0	0
91	43	3,811	1,241	1,152	1,064	1.38	2.07	5,273	753	1,396	598	753	155	931	687
92	88	7,087	2,416	2,819	1,208	1.16	1.28	8,255	221	1,510	262	3,080	463	2,215	503
93	121	8,188	2,842	4,534	1,624	1.41	1.65	11,538	1,895	1,421	1,455	3,603	897	1,049	1,218
94	52	9,193	4,243	3,359	1,414	1.17	1.58	10,784	1,105	2,519	530	2,961	1,282	1,017	1,370
100	69	15,622	6,792	5,887	3,622	1.40	1.80	21,848	1,245	4,641	2,151	6,962	1,868	2,490	2,490
111	53	2,487	1,642	1,455	610	1.82	1.77	4,516	563	1,431	305	739	786	575	117
112	69	7,667	6,667	5,222	1,778	2.03	2.25	15,556	1,278	3,750	1,417	3,500	1,000	3,083	1,528
121	75	10,060	3,085	17,437	1,341	2.36	1.94	23,775	1,408	5,064	2,113	4,762	2,984	4,527	2,917
122	78	9,579	2,702	11,667	1,965	2.04	1.88	19,588	2,241	3,500	1,566	2,211	2,947	3,776	3,347
123	24	6893	3,447	7,755	1,149	2.00	1.71	13,786	574	1,939	1,005	6,031	790	2,010	1,436
124	9	2146	1,431	2,623	0	1.72	1.14	3,696	238	0	0	2,623	0	179	656

Sub-RAD	n	Total Units	Projected by Tree Size			Adjusted/Unit		Total Sites	Adjusted and Projected by Direction						
			Small	Med	Large	MAT	SD		NE	E	SE	S	SW	W	NW
131	4	319	319	160	160	2.75	1.57	877	120	299	0	0	399	60	0
133	13	715	385	495	110	1.56	1.52	1,114	261	220	55	358	0	179	41
134	39	2,587	66	66	0	0.04	0.20	116	0	116	0	0	0	0	0
135	34	2,278	603	1,541	335	1.32	1.68	2,998	184	369	385	1,424	117	184	335
136	2	400	0	0	0	0.00	0.00	0	0	0	0	0	0	0	0
137	29	1,341	1,618	416	185	1.63	1.60	2,185	520	266	0	601	35	555	208
141	56	13,150	6,575	5,401	470	0.89	1.18	11,741	1,585	1,761	2,231	2,818	1,115	528	1,702
142	78	3,135	1,527	804	80	0.70	1.00	2,190	241	362	141	693	211	372	171
143	63	5,956	2,742	1,134	0	0.54	0.69	3,191	402	1,276	331	236	142	425	378
144	75	8,574	4,458	1,600	0	0.58	0.73	4,944	743	772	972	686	629	400	743
145	33	5,919	4,305	897	0	0.70	0.98	4,125	404	1,390	135	717	135	717	628
151	66	9,448	4,151	6,442	573	1.19	1.13	11,273	2,791	1,682	966	1,503	895	2,791	644
152	19	3,206	1,012	4,050	0	1.50	1.38	4,809	591	1,181	506	844	169	1,350	169
153	83	15,168	4,020	14,985	1,462	1.48	1.55	22,387	1,279	5,985	914	5,163	1,051	7,310	685
161	58	9,579	4,129	3,799	165	0.77	0.88	7,391	165	3,014	0	1,074	537	2,188	413
162	31	6,175	2,590	3,785	199	1.02	1.11	6,324	647	1,643	0	2,092	398	1,394	149
163	72	14,426	11,020	6,812	4,007	1.88	1.90	27,099	2,605	5,660	3,807	6,762	1,052	4,959	2,254
164	70	13,474	11,357	11,164	577	1.59	1.26	21,414	2,358	2,984	2,406	4,620	2,791	2,743	3,513
170	10	2,920	3,796	4,672	3,796	6.48	3.64	18,907	803	4,964	584	3,650	3,212	3,139	2,555
181	42	7,979	2,470	2,660	7,409	3.35	2.26	26,739	2,755	4,274	2,422	8,216	1,805	4,512	2,755
191	26	960	849	775	1,255	5.39	6.17	5,178	877	1,440	443	868	425	785	342
192	9	1,091	242	1,333	1,455	5.39	3.42	5,879	212	1,576	970	1,576	606	242	697
193	51	6,015	4,128	3,774	1,179	1.73	1.82	10,408	206	3,391	1,356	2,713	767	1,504	472
211	32	3,802	4,158	1,901	6,772	6.66	4.97	25,337	4,426	2,614	2,317	6,386	2,554	3,267	3,772
212	19	1,118	294	235	1,353	4.04	1.94	4,516	280	809	235	2,030	353	530	280
240	8	1,325	497	2,319	663	3.53	2.96	4,679	663	1,159	331	1,201	166	828	331
250	63	8,270	14,308	4,463	1,050	2.22	2.31	18,345	2,527	3,150	1,871	4,726	1,608	2,658	1,805
Total	2,921	346,186	186,083	212,902	74,564	2.11[a]	0.06[b]	576,156	57,066	113,392	50,326	141,327	50,736	99,447	63,863

[a] Overall mean
[b] Standard error of the overall mean.

APPENDIX G

Table G. Number of Potential Tree Sites Using Forest Service Siting Guidelines.

Sub-RAD	n	Total Units	Projected by Tree Size			Adjusted/Unit		Total Sites	Adjusted and Projected by Direction						
			Small	Med	Large	MAT	SD		NE	E	SE	S	SW	W	NW
12	2	163	0	326	163	5.00	4.24	815	0	82	0	245	163	326	0
21	32	2,548	637	1,513	2,230	3.41	2.93	8,679	239	2,070	1,194	1,115	478	2,946	637
22	29	1,211	418	710	1,629	4.88	3.93	5,909	501	1,670	167	1,169	543	1,566	292
23	51	2,451	817	1,153	2,403	3.66	3.92	8,975	433	2,067	144	2,691	817	2,391	433
31	87	9,789	1,238	2,250	2,138	0.98	1.80	9,592	338	1,913	450	3,376	675	2,391	450
32	62	12,221	788	2,562	0	0.26	0.70	3,154	0	1,183	0	197	0	1,774	0
33	4	139	0	35	0	0.25	0.50	35	0	0	0	0	0	35	0
41	94	10,208	1,738	2,281	1,086	0.67	1.20	6,842	0	869	217	1,738	217	2,932	869
42	120	3,330	389	1,471	389	0.88	1.35	2,928	167	500	278	278	361	1,068	278
43	104	11,144	857	3,750	1,714	0.86	1.33	9,537	321	1,607	321	1,822	964	3,322	1,179
44	113	7,440	198	1,778	922	0.63	1.18	4,691	988	856	263	1,317	329	741	198
51	69	4,238	737	1,781	4,177	3.51	4.19	14,864	369	4,484	798	3,685	798	3,562	1,167
52	133	5,072	343	1,869	2,403	1.84	2.15	9,334	686	2,174	1,068	2,326	648	2,012	419
61	48	3,022	126	2,392	818	1.64	1.63	4,942	0	630	818	1,133	567	1,039	756
62	16	2,875	1,078	3,234	0	1.41	0.97	4,043	0	180	539	539	359	1,527	898
63	25	4,702	0	7,899	752	2.16	1.89	10,156	0	2,445	564	1,881	564	3,385	1,317
71	3	327	109	0	0	0.25	0.43	82	0	0	0	0	0	82	0
73	41	8,565	627	836	0	0.15	0.34	1,306	0	418	0	209	209	470	0
74	1	286	0	0	0	0.00	0.00	0	0	0	0	0	0	0	0
81	31	4,507	1,308	2,908	436	1.15	1.36	5,198	0	1,163	0	436	727	2,726	145
82	57	10,313	181	5,971	1,809	1.12	1.20	11,534	0	2,714	543	3,438	1,628	3,031	181
83	22	1,647	0	674	299	0.95	1.25	1,572	0	225	0	524	225	599	0
84	11	1,193	0	108	108	0.36	1.21	434	0	434	0	0	0	0	0
91	43	3,811	177	975	1,064	1.13	1.87	4,298	266	1,595	177	620	89	1,196	355
92	88	7,087	886	2,497	1,289	0.99	1.37	7,027	0	1,450	81	2,497	322	2,597	81
93	121	8,188	474	3,113	1,489	0.97	1.40	7,934	406	1,218	1,015	2,910	677	1,167	541
94	52	9,193	177	1,945	1,238	0.63	1.20	5,790	0	2,121	0	1,591	707	1,193	177
100	69	15,622	906	4,302	3,849	1.06	1.61	16,528	0	3,622	1,585	5,434	1,132	3,396	1,358
111	53	2,487	141	1,314	657	1.36	1.84	3,390	141	1,361	94	422	751	622	0
112	69	7,667	1,000	4,334	1,778	1.36	2.06	10,417	0	2,667	889	2,333	667	3,083	778
121	75	10,060	671	13,682	1,073	1.73	1.60	17,404	402	4,963	939	3,353	2,280	4,929	537
122	78	9,579	614	8,597	1,719	1.48	1.58	14,215	368	2,947	860	1,719	2,456	4,145	1,719
123	24	6893	1,149	5,457	1,436	1.54	1.50	10,627	0	1,723	574	3,734	574	2,872	1,149
124	9	2146	238	1,431	0	0.75	0.83	1,610	0	0	0	1,192	0	179	238

Sub-RAD	n	Total Units	Projected by Tree Size			Adjusted/Unit		Total Sites	Adjusted and Projected by Direction						
			Small	Med	Large	MAT	SD		NE	E	SE	S	SW	W	NW
131	4	319	80	160	160	2.19	2.12	698	0	239	0	0	399	60	0
133	13	715	165	330	110	1.10	1.41	784	165	220	55	165	0	179	0
134	39	2,587	0	66	0	0.03	0.16	66	0	66	0	0	0	0	0
135	34	2,278	67	1,139	268	0.88	1.17	1,993	0	268	134	1,206	67	184	134
136	2	400	0	0	0	0.00	0.00	0	0	0	0	0	0	0	0
137	29	1,341	370	324	185	0.86	1.23	1,156	139	92	0	370	0	555	0
141	56	13,150	704	3,992	470	0.45	0.89	5,929	0	1,409	939	939	939	528	1,174
142	78	3,135	322	362	80	0.27	0.62	844	0	121	80	201	40	402	0
143	63	5,956	284	662	0	0.15	0.38	874	0	284	95	0	0	496	0
144	75	8,574	229	800	0	0.11	0.31	972	0	343	0	0	114	400	114
145	33	5,919	717	538	0	0.18	0.36	1,076	0	179	0	179	0	717	0
151	66	9,448	1,002	3,436	716	0.67	0.94	6,334	0	1,575	429	1,145	143	2,899	143
152	19	3,206	675	3,375	0	1.21	1.24	3,881	0	1,181	506	506	169	1,350	169
153	83	15,168	2,193	13,158	1,827	1.34	1.67	20,285	0	5,848	731	4,020	731	8,406	548
161	58	9,579	1,156	3,633	165	0.52	0.85	4,996	0	2,147	0	330	165	2,188	165
162	31	6,175	797	3,187	199	0.71	0.93	4,382	0	1,195	0	1,394	398	1,394	0
163	72	14,426	2,004	5,610	3,406	1.20	1.60	17,331	601	4,007	2,404	4,007	601	5,310	401
164	70	13,474	577	8,854	577	0.82	0.93	11,020	0	2,117	770	2,117	1,347	2,743	1,925
170	10	2,920	1,460	3,212	3,796	5.38	3.47	15,695	0	4,964	292	2,920	2,920	4,307	292
181	42	7,979	190	1,900	7,409	3.04	2.35	24,269	2,280	3,990	1,710	7,789	1,520	4,512	2,470
191	26	960	111	665	1,071	4.13	5.50	3,960	443	1,329	332	591	332	785	148
192	9	1,091	0	485	1,333	4.11	3.22	4,485	0	1,940	0	1,455	485	606	0
193	51	6,015	590	3,184	1,179	1.19	1.59	7,165	0	2,949	354	1,769	590	1,504	0
211	32	3,802	713	832	6,178	5.23	4.29	19,901	2,495	2,970	475	5,941	1,782	3,624	2,614
212	19	1,118	0	235	1,295	3.68	1.73	4,119	177	765	0	1,942	353	647	235
240	8	1,325	0	1,159	663	2.38	2.13	3,147	0	1,159	0	497	0	1,325	166
250	63	8,270	2,494	2,888	394	0.72	1.15	5,940	0	1,181	131	1,181	394	2,658	394
Total	2,921	346,186	34,919	157,331	70,548	1.50[a]	0.07[b]	395,163	11,923	93,888	23,018	94,589	33,418	111,085	27,242

[a] Overall mean
[b] Standard error of the overall mean.